DOES BROADBAND MATTER FOR RURAL ENTREPRENEURS OR 'CREATIVE CLASS' EMPLOYEES?

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"Whatever you do, work at it with all your heart, as working for the Lord, not for human masters." Col. 3:23

"Trust in the Lord with all your heart and lean not on your own understanding; in all your ways acknowledge Him, and He will make your paths straight." Prov. 3:5-6

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Abstract: Broadband, or high-speed Internet, has changed the way our society operates; yet there are still parts of rural America where the connection is lagging behind. Closing the ‘digital divide’ is still a priority on rural America’s agenda, with government policies focusing on providing broadband infrastructure to unserved (or underserved) areas. An unanswered question, however, is whether a relationship exists between broadband availability and the existence of entrepreneurs or ‘creative class’ workers in rural communities. These types of workers have been shown to be particularly important for economic growth in rural areas. One relevant hypothesis is that some threshold related to broadband exists (a specific download speed, or number of providers) that is positively related to the existence of rural entrepreneurs; such a finding would have meaningful implications for future U.S. broadband policy. This research explores this relationship using county-level data from the 2012 National Broadband Map and measures of entrepreneurship and creative class employees from the Census and ERS. Spatial econometric tools are used to assess the cross-section relationship as of 2012. First-differenced regressions are also used to determine whether increasing levels of broadband have influenced changes in entrepreneurship or creative class employees in rural areas over time. Results indicate wired broadband availability is important to entrepreneurs in rural areas. The opposite is true for creative class employees in rural areas – broadband adoption, and wired/ wireless availability actually has a negative influence. These results suggest that the direction is not always positive, which is an interesting finding and one that should be taken into account as specific rural development policies are developed.

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CHAPTER I

INTRODUCTION

For many, the ability to connect with one another via the Internet is intrinsic to our everyday lives. Connecting via social media platforms, communication thru email, and conducting business online is an integral part of 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

[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. Recently, the FCC changed the broadband definition to 25Mbps download and 3Mbps upload.

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[2]' workers to foster economic growth. Entrepreneurs, especially high-growth entrepreneurs, bring added economic value to a community (Henderson 2002). Innovation and thinking 'creatively' have been recently shown to be driving forces for economic growth in cities (McGranahan and Wojan 2007a).

Other rural development policies focused on recovering jobs lost during the Great Recession of 2007. During the beginning of the recovery, metro and non-metro[3] employment levels grew at similar rates. However, in 2011 net job growth in non-metro areas dropped to roughly zero, while metro employment grew at an annual rate of 1.4 percent (USDA 2013). The lack of job growth in non-metro areas initiates concern not only for those living in rural areas, but also for economic developers and policy makers. Some have suggested that improving broadband access in rural areas would lead to improved employment situations (Stenberg et al. 2009).

In 2008, it was estimated that 55 percent of urban U.S. adults had residential broadband access, juxtaposed with only 41 percent of adults in rural households (Stenberg et al. 2009). Since 2008, legislation has been passed with the intention of bridging the broadband gap between urban and rural areas by improving both broadband availability and adoption. This legislation includes the American Recovery and Reinvestment Act (ARRA) passed by Congress in February 2009, which aimed to create new jobs and spur economic activity, hopefully leading to long-term

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[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."

[3] The U.S. Census Bureau defines (at the community level) an urbanized area as one with greater than 50,000 people; a urban cluster as areas with populations more than 2,500 but less than 50,000 people; rural as populations less than 2,500. The Office of Management and Budget, defines a Metropolitan Statistical Area (MSA) as having a population greater than 50,000. A county is considered Metropolitan if it contains an MSA or if 25% of the county commutes to an MSA. Other counties are considered Non-metropolitan, with micropolitan having an urban cluster of 10,000 or more and non-core as everything else.

growth. A portion of the ARRA legislation was focused on expanding the broadband network across the U.S. through the Broadband Technology Opportunities Program and the Broadband Initiatives Program. Over 7 billion dollars was invested in these broadband programs (NTIA 2010). One product of this ARRA funding was the National Broadband Map, which for the first time provided a low level of detail into exactly where broadband access was and was not available.

According to December 2013 data from the National Broadband Map, 96.6 percent of rural residents, and 100 percent of urban residents have availability to wireline or wireless broadband (NBM 2014). According to theses numbers, the rural-urban broadband gap does not seem to be apparent; however, when looking solely at wireline technologies, the gap substantially increases (FCC 2014). Wireline technologies include DSL, copper, cable, and optical/fiber connections, while wireless technologies include terrestrial fixed and terrestrial mobile – including cellular access (FCC 2014). In December 2013 around 78 percent of rural residents had access to wireline broadband, while urban residents had close to 100 percent wireline broadband availability (NBM 2014). Thompson and Garbacz (2011) looked at the economic impacts of wired versus wireless broadband and found mobile broadband (wireless) has an important direct effect on GDP, while fixed broadband (wired) has an effect no different than zero. However, wireless access in rural areas often incorporates shared user access arrangements that can be easily overloaded by bandwidth-intensive applications, therefore can be inferior for tasks such movie downloads, videoconferences for telecommuters, and online courses (LaRose et al. 2007).

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’ employment. This research will attempt to improve the understanding of the relationship between broadband availability/adoption and their 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 relationship between broadband and levels of creative class employment and entrepreneurship across rural America. The overall objective of this research 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:

1. Determine whether or not there is a relationship between current levels of entrepreneurship and creative class workers and broadband in rural areas.

Because wireless and wired broadband technologies have different functions and different user accessibilities, a second objective is to:

2. Assess whether there is a distinction between wireless and wired broadband availability in this relationship.

Finally, the direction of causality is a concern. Entrepreneurs and creative class workers might be drawn to areas were broadband infrastructure is already established. Goetz et al. (2012) also noted that while entrepreneurship may improve local economic activity, a strong local economy might in fact attract entrepreneurs as well. In fact, the presence of entrepreneurs may lead to investments in broadband by infrastructure providers. This leads to questions about causality and leads to the third objective:

3. Determine whether the relationship between broadband and entrepreneurship/creative class is a causal one, and if so, in which direction causality runs.

Hypotheses

Recent studies have aimed at moving beyond correlation between broadband and economic measures to determining if there is a causal relationship (Whitacre, Gallardo, and Strover 2014a; Dinterman and Renkow 2014). Whitacre, Gallardo, and Strover (2014a) examined broadband availability/adoption and used propensity score matching to determine if causality existed between broadband and economic growth in rural areas of the United States. While data limitations and other unobservable influences prevented any strict claims of causality, the authors argue that high levels of broadband adoption in rural areas potentially led to higher income growth between 2001 and 2010, and decreased unemployment growth (Whitacre, Gallardo, and Strover 2014a). Thus, the authors argue that the focus should be on broadband adoption as opposed to availability.

Similarly, Dinterman and Renkow (2014) used county-level broadband availability data from 2008-2012, to try and determine causality between broadband and increased economic growth. They do not find a significant relationship between employment growth in (2010-2012) and broadband growth in the previous time period (2008-2010), and therefore they are unable to detect meaningful predictive causality (Dinterman and Renkow 2014). These contradictory findings and lack of focus on entrepreneurship or creative class employees do not lead to firm hypotheses about the relationship between broadband and specific types of employment. The following hypotheses are established in order to formally test these relationships.

- H1: A positive relationship exists between wired broadband *adoption* and

  H1a: entrepreneurship measures in rural America.

  H1b: creative class employment in rural America.

- H2: A positive relationship exists between wired broadband *availability* and

  H2a: entrepreneurship measures in rural America.

  H2b: creative class employment in rural America.

Although wireless broadband is not seen as a substitute for wired, the difference between the two in terms of economic impact has not been explored.

- H3: There is no statistically significant relationship between wireless broadband availability and either entrepreneurship measures/ creative class employment in rural America.

However, the question remains whether areas with higher levels of broadband infrastructure attract creative class employees and entrepreneurs, or whether the opposite happens: the presence of creative class workers and entrepreneurs encourage investment in broadband availability. Additionally, do areas with a higher population of entrepreneurs and creative class workers drive up the broadband adoption rate, especially in rural areas with correlating higher abundance of natural amenities? This leads to the final hypothesis:

- H4: No causal relationship exists between broadband availability and

  H4a: entrepreneurship measures in rural America.

  H4b: creative class employment in rural America.

CHAPTER II

REVIEW OF LITERATURE

Early Rural Broadband Research

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[4]. 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 2013a).

Early telecommunications research, beginning with traditional Internet connection, focused on equality, and pushed to close the emerging ‘digital divide’ gap (NTIA 1995, 1999). As dial-up Internet access gave way to high-speed Internet, more commonly known as broadband, around 2000, rural areas continued to lag behind central cities and urban areas in rates of broadband adoption. The broadband adoption rates in these areas were at 7.3 percent, 12.2 percent and 11.8 percent, respectively (NTIA 2000). In 2011, 71 percent of the rural population had access to wireline broadband service, compared with 98 percent of the urban population having access to the same speed of broadband. Further, the rural-urban gap became larger as

[4] Broadband was defined as 3 Mbps or less when this estimation was made.

broadband speeds increased (NTIA 2013b). However, wireless broadband availability – driven by dramatic growth in the cell phone industry – is essentially ubiquitous in both rural and urban areas (NTIA 2013b).

Most of the current federal policies are aimed at increasing broadband infrastructure in rural areas. The American Recovery and Reinvestment Act (ARRA) of 2009 dedicated $7 billion in subsidies to stimulate rural broadband coverage (Egan 2014). Two specific programs within the ARRA sought to expand and improve broadband infrastructure including the Broadband Technology Opportunities Program (BTOP), run by the NTIA, and the Broadband Initiatives Program (BIP). Overall, however, the ARRA dedicated most of its funds towards infrastructure, with less than seven percent towards programs focused on increasing broadband adoption (Dickes, Lamie, and Whitacre 2010). More 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 of dollars 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. Increasing broadband infrastructure in rural America is an integral part to closing the digital divide; however, educational programs aimed at helping those in rural America discover the advantages of adopting broadband may be the last piece to bridging the rural-urban broadband gap.

Rural areas are typically characterized as having lower levels of education, higher levels of poverty and higher concentrations of farming communities (USDA 2013). These demographic, economic and educational differences are key wedges in the ‘digital divide’ (Whitacre and Mills 2007). Specifically, Whitacre and Mills (2007) found that as of 2003, income differences accounted for over 22 percent of the rural-urban divide and differences in education and network externalities[5] were among the most important contributors to the high-speed access divide. A more 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.

Previously, a significant amount of research has been dedicated to looking at the relationship between broadband and economic growth, however, the literature is lacking as it pertains to rural areas. Some studies have examined the relationship between broadband and employment, but none have focused specifically on entrepreneurship and creative class workers. The following sections will highlight the research conducted on broadband and economic growth, specifically employment growth, and also how both entrepreneurship and creative class measures might be useful from an economic development standpoint.

Broadband and Economic Growth

Several studies have found broadband deployment serves as an indicator of local economic activity (Gillett et al. 2006; Stenberg et al. 2009). Kolko (2012) and Jayakar and Park (2013) find a positive relationship between broadband expansion and local employment and population growth, as well a negative relationship between broadband and unemployment. This positive economic growth is found to be stronger in areas with lower population densities and in industries that rely more on information technology (Kolko 2012). Likewise, Mack and Faggian (2013) find technological change, including broadband access, positively affects productivity in areas with highly skilled occupations and higher levels of human capital. The introduction and

[5] Network externalities is the concept that each network member's utility increases as more members enter the network (Whitace and Mills 2007).

diffusion of broadband had an important impact on growth in GDP per capita when 25 OECD[6] countries were examined from 1996 to 2007 (Czernich et al. 2011).

There has been some research focusing specifically on rural areas and broadband, in the context of economic growth (USDA 2013). Broadband is becoming increasingly important to rural areas due to the adoption of e-commerce and farm businesses purchasing inputs and on-line sales (Stenberg et al. 2009). While there seems ample evidence of positive economic impacts from expanded broadband deployment and adoption, data limitations and lag effects on job creation makes formally assessing broadband's impact difficult to measure (Holt and Jamison 2009). Whitacre et al. (2014a) make the case for a causal relationship between rural broadband adoption and economic growth, but recognize several limitations in their approach.

Broadband and Employment Growth

Many early studies tested the hypothesis that broadband can lead to job creation. However, the results have not always been consistent. When examining 48 contiguous states from 2003-2005, the impact broadband had on job creation was concentrated in the service industry, including jobs in financial services, education and healthcare (Crandall, Lehr, and Litan 2009). Gillett et al. (2006) observed that the magnitude and impact of broadband on employment increases overtime. Atasoy (2011) found that gaining access to broadband in a particular county is associated with about a 1.8 percentage point increase in the employment rate and is larger in rural areas.

Dinterman and Renkow (2014) used county-level data from 2008 until 2012 to examine the link between broadband and local employment growth. They specifically attempt to assess whether broadband growth causes economic growth, or vice versa. Their approach to determine

[6] The Organization for Economic Co-operation and Development (OECD) is an organization of 34 countries that aim to promote policies that will improve the economic and social well-being of people around the world.

causality was to use data from two different time periods. However, their econometric results indicate no significant relationship between 2010-2012 employment growth and 2008-2010 broadband growth. Similarly, they did not find a significant relationship between 2008-2010 employment growth and 2010-2012 increases in their broadband measures used. Hence, they found no indication of a causal relationship.

Jayakar and Park (2013) used an econometric model to examine the effect of broadband availability on the unemployment rate at the county level. Their results indicate broadband availability is correlated with small changes in unemployment. They found that counties with higher broadband availability in 2012 have lower unemployment rates and also exhibit lower increases in unemployment from 2008 to 2012 (Jayakar and Park 2013).

Recent work has examined the link between broadband and the location of knowledge intensive firm clusters (Mack 2012; Mack, Anselin, and Grubesic 2011). Mack (2012) evaluated the relationship between the spatial distribution of broadband providers and the presence of knowledge intensive firm clusters in US counties. Results of this study indicate both broadband and knowledge clusters are located predominantly within core counties of large metropolitan areas (Mack 2012). Mack and Faggian (2013) evaluated the link between broadband and worker productivity for the 2000-2007 time period. Their primary finding was that broadband only produces positive productivity impacts when used by more educated or skilled occupations. Each of these findings has implications for rural communities, although these studies did not focus on these areas.

By contrast, Whitacre, Gallardo, and Strover (2014b) did focus on rural areas. Using spatial error models and 2011 data, they 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.

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. However, research is lacking on whether broadband can contribute to the strategies, and effectively attract entrepreneurs and creative class workers.

Creative Class and Entrepreneurs in Rural areas

Creative Class

Rural communities plagued by 'brain drain' are encouraged to attract 'creative class' workers as a means to improve economic development (McGranahan, Wojan and Lambert 2010). The idea behind attracting creative and innovative employees stems from the idea that creativity and innovation are thought to be indicators of positive economic development. While low creative class non-metropolitan counties only saw an 18 percent increase in employment between 1990-2004, high creative class non-metropolitan saw a 44 percent increase (Figure 1; ERS USDA).

Figure 1. Job Growth in Creative Class Non-metro Counties

High creative-class nonmetro counties gained jobs faster than other nonmetro counties

County type	Creative class counties, 1990: Low/middle	Creative class counties, 1990: High[1]
	Percent change in jobs, 1990-2004	
Metropolitan	31	39
Nonmetropolitan	18	44
Not adjacent to metro	16	40
High-amenity county[1]	26	60
Recreation county	32	61
Not recreation county	16	28
Percent college graduates[1]	16	46

[1] Ranked in top quarter of all counties.
Source: Bureau of Economic Analysis, Regional Economic Information System files.

However, quantifying the role the creative class plays in population and employment gain is difficult given all the factors involved in such growth.

In the book The Rise of the Creative Class (2002), Richard Florida presented that urban economic development depends largely on people whose occupations require creative thinking. Therefore, a possible strategy for rural development is to attract and retain those types of workers. Florida (2002) believes people in these occupations tend to seek a higher quality of life, and are consequently drawn to diverse cities and outdoor recreation opportunities. Critiques of Florida's 'creative class' measure, however, contend that it is merely another way to capture higher education (McGranahan and Wojan 2007b).

In 2007, McGranahan and Wojan refined the creative class measure by removing occupations who often require creative thinking but are also proportional to the residential population, for example, teachers, judges, and medical doctors. While the creative class is mostly found in urban areas, as previously mentioned, it was found to be associated with growth in rural areas from 1990-2004 (McGranahan and Wojan 2007a). The combination of entrepreneurs, with a share of the creative class, 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 2007a). This could have effects on the adoption of broadband in rural areas. However, it is not clear if those who more readily adopt choose to live in creative class areas, or if the high creative class areas spur new technology adoption (McGranahan and Wojan 2007a). 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. The hypotheses in this paper will help answer this question.

Entrepreneurs

Similar to attracting creative class workers, increasing entrepreneurship has long been thought of as a means to increase economic growth – especially for rural communities. Federal, state, and local programs geared toward entrepreneurs and small business owners and tax breaks given to entrepreneurs' shows confidence in these workers to foster local jobs, wealth and new creativity. For example the US Small Business Administration (SBA) offers financial assistance to help potential entrepreneurs obtain loans and to receive grant funding (SBA 2014).

An entrepreneur as defined by Merriam-Webster Dictionary is one who organizes, manages, and assumes the risks of a business or enterprise. However, for researchers, evaluating entrepreneurship is often times complicated due to the question of how to specifically define and measure entrepreneurship (Goetz and Rupasingha 2010).

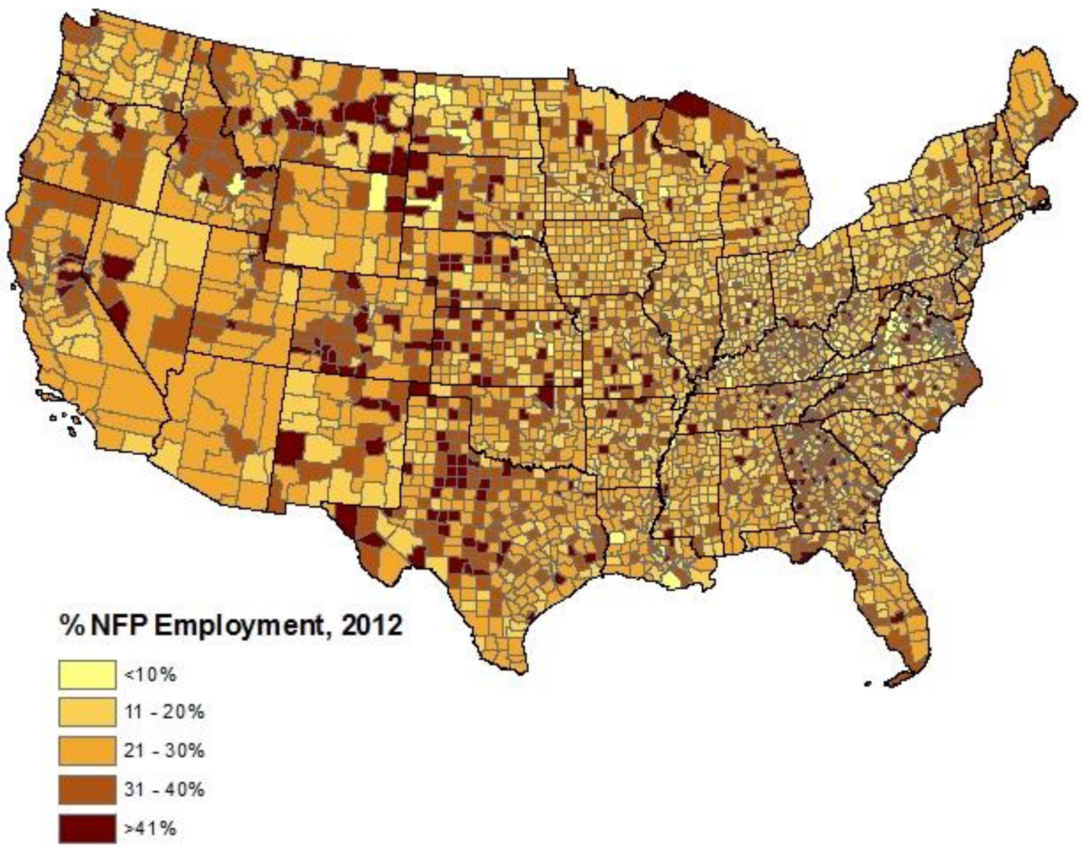
Two important components of regional entrepreneurship are the dispersion of entrepreneurs (breadth), and the value of entrepreneurial activities to the community (depth) (Low 2004). Breadth is measured as the percentage of jobs that are entrepreneurial, while depth is measured by the income generated by the job or value added activities. Rural areas have been shown to be lagging in entrepreneurial depth (Low 2004); however, self-employment seems to be increasing and continues to have a growing, positive impact on rural counties (Gallardo 2014).

Shrestha, Goetz, and Rupasingha (2007) found that lagged non-farm proprietorship formations lead to increased job growth. However, they note the positive growth appeared to be stronger when the U.S. was recovering from a recession, and jobs created per additional proprietors from 1995-1999 were more pronounced for metropolitan counties (Shrestha, Goetz, and Rupasingha 2007).

In response to the Great Recession of 2007-09, rural America experienced increases in jobs and a declining unemployment rate; however, metro counties are gaining jobs twice as fast as their rural counterparts (Bishop 2014). While rural areas saw net job growth increases during the beginning of the recovery period, in 2011 it tapered off to near zero (USDA 2013).

Figure 2 (below) shows the percent non-farm proprietors at the county level for the continental U.S. in 2012.

Figure 2. Percent Employed as Non-Farm Proprietors, 2012



Markeson and Deller (2012) note that proprietorship growth is spatially clustered and spatial spillover effects matter. They also found rural areas with warmer temperatures and a drier climate tended to experience higher levels of entrepreneurship growth (Markeson and Deller 2012). The NFP map above (Figure 2) further stresses that space and location matter – to entrepreneurs starting businesses and therefore must also be taken into account when analyzing data for this research.

This research specifically is interested in the relationship between the percent non-farm proprietors (entrepreneurs) and broadband availability/ adoption in rural areas.

Gallardo (2014) and Low (2004) emphasize the importance that broadband access and effective uses of broadband applications have on 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.

Wage Gap in Self-employment Workers and Broadband Users

A wage gap facing rural America is emerging between average non-farm proprietor and average wage-and-salary worker earnings (Rupasingha and Goetz 2011). As previously mentioned, broadband expansion is believed to have positive effects on entrepreneurs in rural areas, however, there has also been some evidence that broadband expansion is likely to only increase the gap in the labor market between skilled and unskilled workers (Mack 2012).

Atasoy (2011) used OLS regression to analyze the effect of the expansion of broadband access from 1999 to 2007 on labor market outcomes throughout the United States. When controlling for time and county fixed effects, Atasoy (2011) found broadband has more positive impacts on higher skilled labor sectors, which might not be as abundant in rural areas.

Non-farm proprietorships (NFPs) as proxy for self-employment/ entrepreneurship

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). Goetz, Fleming and Rupasingha (2012) examine the lag structure effect of self-employment on wage and salary employment growth across U.S. counties, and find that self-employment is growing. These studies demonstrated that using NFPs can be an effective way to measure entrepreneurship in rural areas – and that this type of work has positive impacts in rural America. The aforementioned studies exhibit positive results, however, Henderson and Weiler (2010) also note that the positive economic impact from entrepreneurs often don't occur instantly, but over a long period of time. Therefore, the positive economic impacts from entrepreneurs can be captured over a longer economic time frame. However, there is little empirical research on whether broadband is important to attracting entrepreneurs to rural areas.

Spatial Models

Traditionally, ordinary least squares regressions have been used to estimate the effects of broadband diffusion on unemployment rates at the county level, and also employment growth in non-farm private sectors and output growth in non-farm private sectors at the state level (Grubesic 2002; Crandall, Lehr, and Litan 2009). Studies using OLS have noted problems with controls and the potential endogeneity of supply factors (Aron and Burnstein 2003). In reference to broadband availability and adoption, space and location matter. Heavily populated areas generally have higher rates of broadband availability and adoption, and when mapped, pockets of high and low levels can be easily observed (Whitacre, Gallardo, and Strover 2013a).

Figure 3 shows the distribution of broadband adoption across the United States. Broadband adoption appears to be most prevalent in areas with high population, such as the Northeast, and pockets of high / low adoption can be seen across the country.

Figure 3. County-level Household Broadband Adoption Rates, 2012

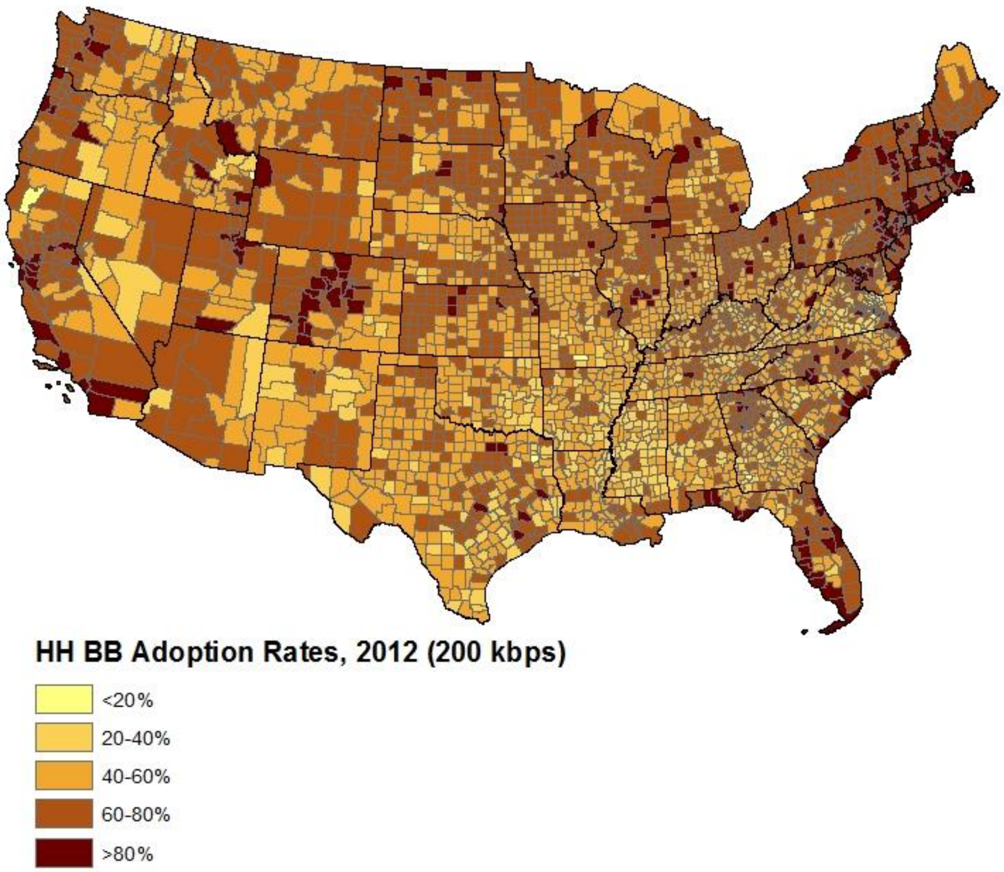
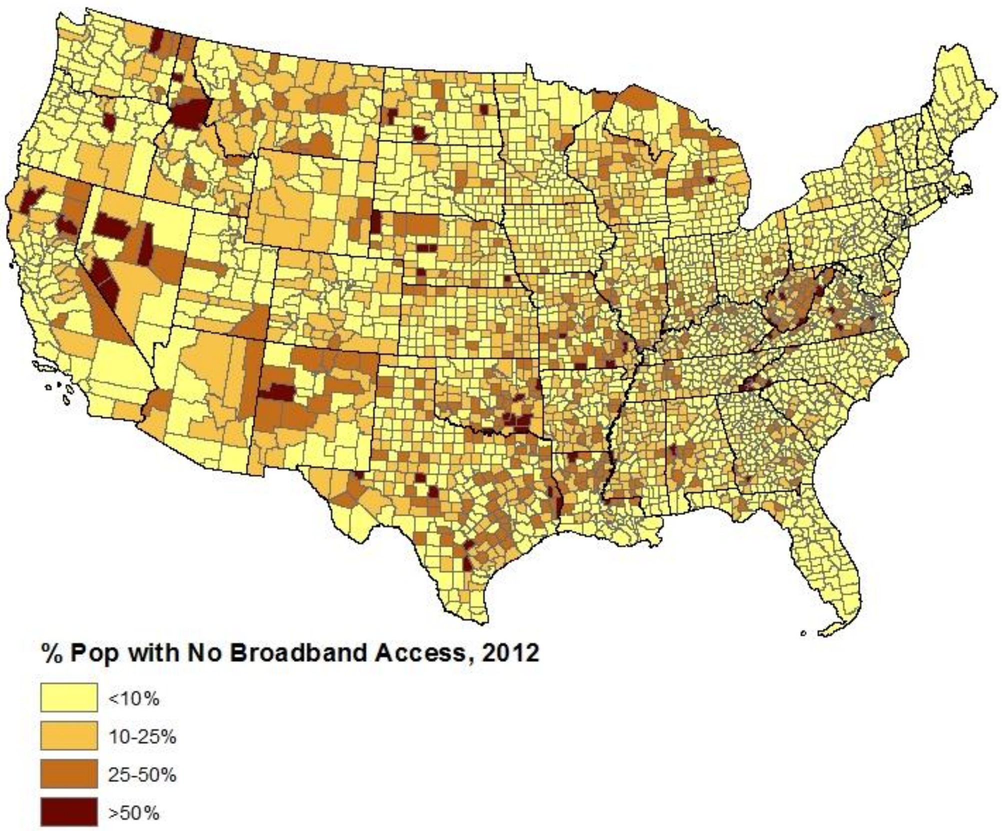


Figure 4 (next page) depicts the percent of the population in each county with no access to wired broadband.

Figure 4. Percent of Population with No Access to Wired Broadband, 2012



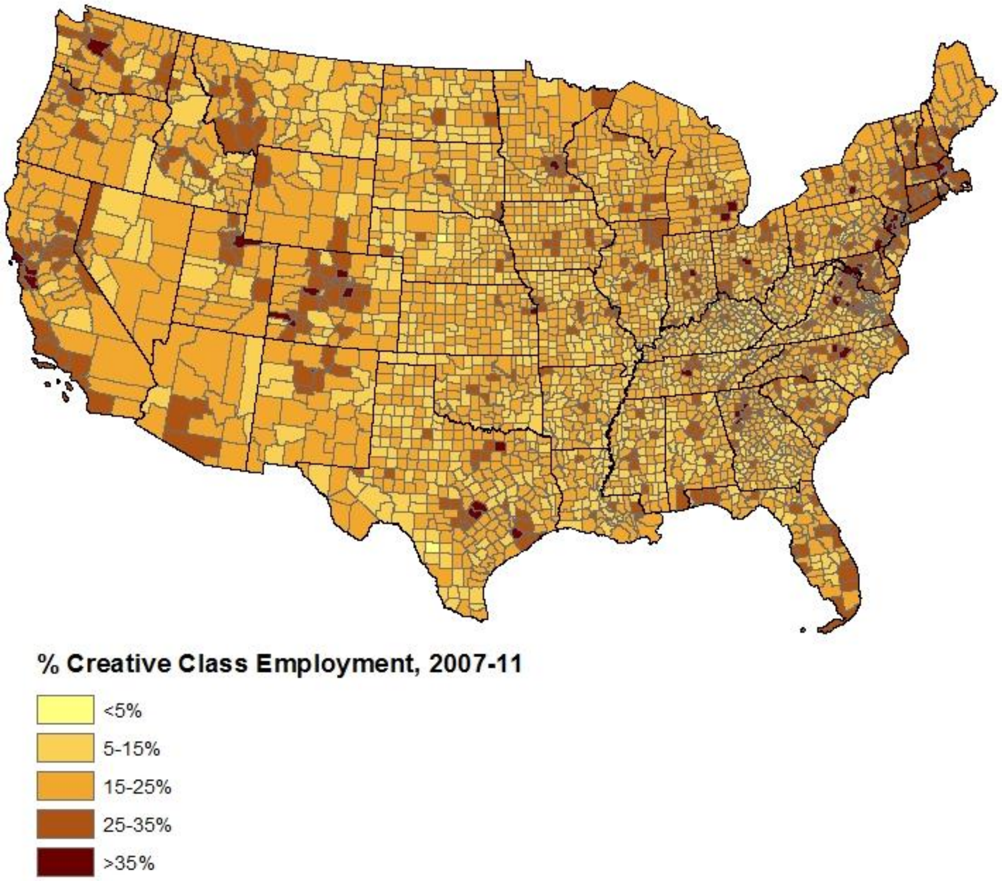
These figures clearly demonstrate spatial patterns. This leads to the concept of spatial autocorrelation, which, if present, violate the assumption of statistically independent observations typically present in OLS models.

In a seminal paper that demonstrates the importance of controlling for spatial effects, Loftin and Ward (1983) recalculated a previously conducted study that used OLS with a spatial error model. When spatial weight matrices were included, the coefficients for the population density variables (the primary variables of interest) were substantially reduced. 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).

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 2014b).

Several studies also suggest that entrepreneurship in a specific area creates positive spillovers, including job growth in neighboring counties (Henderson and Weiler 2010; Drucker 1985; Rogers 2003; Rupasingha and Goetz 2011). This presence of spatial spillovers creates a pattern of spatial dependence that requires a spatial econometric approach (Rupasingha and Goetz 2011). When mapped, the percent employed as non-farm proprietors and creative class exhibit spatial characteristics (Figures 2 and 5, respectively).

Figure 5. County-level Share of Creative Class Employees, 2007-11



Pockets of 'creative class' workers are found in large cities, especially those with high natural amenities as well (McGranahan and Wojan 2007a). In Figure 5, these are observable in the Northeast and around Denver, among other places.

Jayakar and Park (2013) address the effect of broadband availability on the unemployment rate at the county level in the United States; however they did not consider the aforementioned spatial modeling techniques. 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, and if so, the relationship may be appropriately estimated using spatial econometric models, which are further detailed in the methodology section.

CHAPTER III

METHODS AND PROCEDURES

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			
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	2004
% 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

Data

Creative Class Data

"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 2007b); 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 2007b).

The reformed ERS data downloaded for this research used standard occupation codes identified by descriptors from O*Net[7] (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. However, one potential weakness of the reformulated data is the inclusiveness of jobs which typically would not elicit 'creating' new ideas, for example, "meat, poultry and fish cutters and trimmers, furniture finishers, and amusement and recreation attendants" (O*Net 2015).

Both the 2000 and 2007-11 datasets include the total number employed, the number of creative class employed, the share of creative class employees, and the bohemian[8] share of employees. For this research, the 2007-11 pooled 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.

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[7] 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.

[8] 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).

Entrepreneurship Data

Similar to previous studies, the percent of non-farm proprietors is used as a proxy for entrepreneurship (Rapasingha and Goetz 2011, Goetz et al. 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. Note that this is only a measure of breadth (not depth) of 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 and relevant variables to broadband adoption and entrepreneurship are included in the dataset. Specific data from the ERS includes natural amenity rank, metropolitan and non-metropolitan county classification, unemployment rates, and total population. The Census datasets utilized in the models described below include median household income, race, age, and education classifications.

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 the percentage of the population with access to no providers, one or more, two or more providers, etc. – up to eight providers. Demographic data is also included within the "Analyze Table" dataset, and will supplement the ERS 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 2014b). 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 based on the number of connections per 1,000 households[9]. 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.

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

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[9] The six categories are defined on the number of broadband 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. Thus the categories range from < 20% to > 80% adoption by households in the country.

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. 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:

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

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 a 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 GeoDa, with entrepreneurship and creative class as the 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 that 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. Interacting a non-metro dummy variable with these terms allows for the identification of the more rural counties that meet these thresholds. 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 with access to wireline > 85% = 1	0.66	3,142	NBM
NMHiAvail	If non-metro county and percent of HH with 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 with 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

Thus, in 2011, 66 percent of all counties demonstrated broadband access of greater than 85 percent. Fifty-seven percent of non-metro counties demonstrated this level of availability. Thirty-eight percent of all counties had greater than 60 percent of their households with broadband connections, compared to 25 percent of non-metro counties.

The ‘HiAvail’ and ‘NMHiAvail’ measures are similar in 2012. Interestingly, however, the adoption categories increase significantly. Forty-six percent (up from 38 percent) of all counties had greater than 60 percent of their household with broadband connections, compared to 34 percent of non-metro counties (up from 25 percent). In the one year from 2011 to 2012 we see an increase in the mean values for high broadband availability and adoption, both overall and in non-metro areas.

To test if a positive relationship exists between wired broadband adoption and entrepreneurship in rural America (H1a), 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 dummy variable, $HIADOPTNM_i$ 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.

A similar model can be used for creative class employment. To test if a positive relationship exists between wired broadband adoption and creative class employment in rural America (H1b), 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 dummy variable, $HIADOPTNM_i$ 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 (2007-11). Note that 2011 is the earliest version of the National Broadband Map.

Similar methodologies can be used to test the relationship between wired broadband *availability* and entrepreneurship/ creative class measures. Equations to test hypotheses H2a and H2b 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.

To test H3, if there is no statistically significant relationship between wireless broadband availability and either entrepreneurship measures/ creative class employment in rural America, similar methodologies are used, however, high availability ($HIAVAIL_i$) for *wireless* would be defined as greater than 99 percent of households with wireless broadband availability.

Table 3. Wireless Broadband Availability Summary Statistics

2011

Name	Description	Mean	Observations	Source
HiWireless	If percent of HH with access to wireless (excluding satellite) > 99% = 1	0.50	3,142	NBM
NMHiWireless	If non-metro county and percent of HH with access to wireless (excluding satellite) > 99% = 1	0.39	1,976	NBM

2012

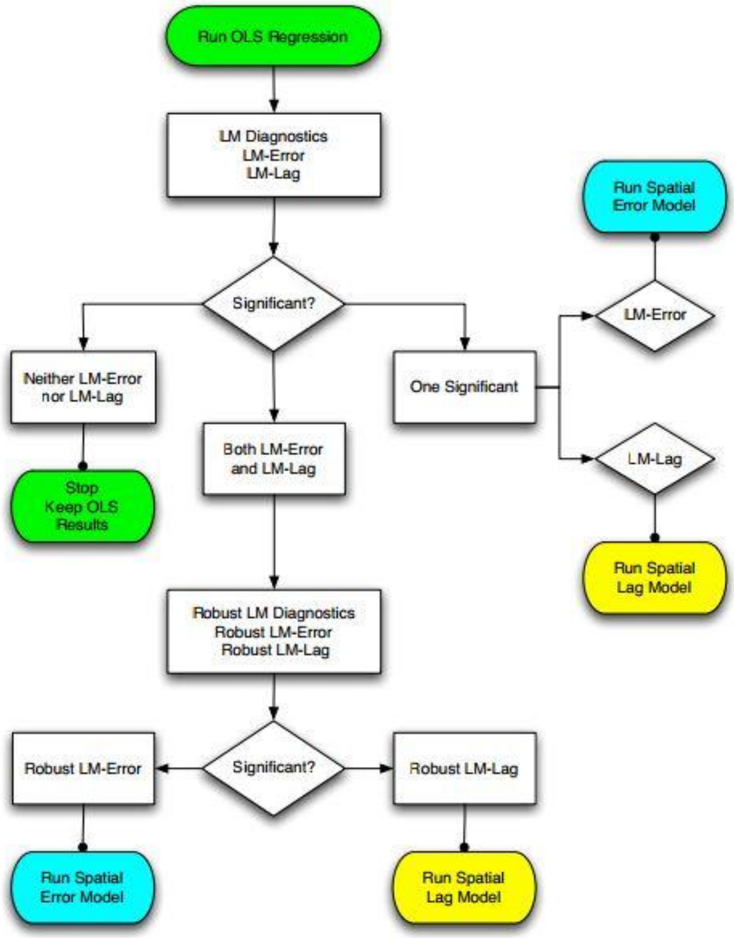
Name	Description	Mean	Observations	Source
HiWireless	If percent of HH with access to wireless (excluding satellite) > 99% = 1	0.59	3,143	NBM
NMHiWireless	If non-metro county and percent of HH with access to wireless (excluding satellite) > 99% = 1	0.49	1,976	NBM

Table 3 outlines the summary statistics for wireless broadband availability in 2011 and 2012. In 2011, 50 percent of all counties demonstrated wireless broadband availability of greater than 99 percent. Thirty-nine percent of non-metro counties demonstrated this level of availability. A year later in 2012, 59 percent of all counties had greater than 99 percent of their households having availability to wireless broadband, compared to 49 percent of non-metro counties. This increase in wireless access is striking when compared to wireline (Table 2), which showed only small growth.

While each of these models has been written in terms of simple OLS, they will each be tested for the most appropriate spatial specification.

Examining the Moran's I, Lagrange Multiplier (lag), Robust LM (lag), Lagrange Multiplier (error), and Robust LM (error) will indicate whether a spatial lag or spatial error model is most appropriate. Figure 6 lays out the process for determining which spatial model to use, as defined by Anselin (2005). One would first run diagnostics on a simple OLS regression, looking at the significance of the LM for the lag and error terms. If the LM value is significant for the error and not the lag, the error model would be appropriate and should be tested. The opposite holds if the lag model is found to be significant and the error model is not significant. If neither values are significant, the OLS model results are appropriate. However, if both LM values are significant one would examine the Robust LM for both the lag and error models and choose to run the one with the respective highest significance. Moran's I (a value denoting the aggregate level of spatial association) is not helpful in determining which model to use; however, when the value is significant, there is evidence of spatial autocorrelation.

Figure 6. Spatial Regression Decision Process, Anselin (2005)



Assuming the Moran's I value is high and significant, and both the LM's for the lag and error models are significant, further controls are needed to correct for the defined spatial dependence or spatial heterogeneity. In order to control for spatial factors one can use either the spatial lag or spatial error model, as described above.

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

One technique that can be used to evaluate a potentially causal relationship between broadband availability/ adoption and measures of creative class and entrepreneurship is first-differenced regression (H4). 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 wasn't widely available in 2000, this analysis assumes it was negligible, and zero will be used (Pew Research Center 2015). The dependent variable (left hand 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 (H4b) 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 during the 2000 – 2011 time period.

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 (or adoption) categories between 2000 and 2012 (H4a).

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 4 shows the summary of data statistics for 2012.

Table 4. 2012 Summary of Data Statistics

Name	Mean			
	Overall	**Metro**	**Non-metro**	
Creative Class 07-11 (% of jobs)	0.18	0.22	0.16	***
Entrepreneurship (%NFP)	0.26	0.24	0.26	***
Total Population (2010)	98,232.75	224,894.70	23,427.84	***
MHI	45,644.41	52,447.24	41,626.75	***
White (%)	0.84	0.81	0.85	***
Black (%)	0.08	0.1	0.07	***
Hispanic (%)	0.08	0.09	0.08	**
Asian (%)	0.01	0.02	0	***
Other (%)	0.06	0.05	0.06	**
HS Diploma Only (%)	0.35	0.32	0.37	***
Bach. Degree or Higher (%)	0.19	0.24	0.17	***
Age 5-19 (%)	0.21	0.21	0.22	***
Age 20-34 (%)	0.19	0.2	0.19	***
Age 35-59 (%)	0.31	0.33	0.3	***
Age 60+ (%)	0.23	0.22	0.24	***
Unemployment Rate	0.08	0.08	0.08	
Broadband Availability (% with wired BB avail. to them)	0.87	0.93	0.84	***
Broadband Adoption (1-5)	3.43	3.77	3.23	***
Observations	3,143	1,167	1,976	

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

In 2012 metro counties have more creative class employees but non-metro counties have more entrepreneurs. Metro counties also have higher education levels, along with having greater broadband availability and more people adopting broadband.

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.

Before spatial models are run, GeoDa can be utilized to examine bivariate Moran's I and bivariate LISA (local indicators of spatial association) scatter plots and maps between the variables of interest, in our case broadband availability/ adoption and the percent employed in creative class and non-farm proprietors[10]. Bivariate LISA cluster maps are an extension of the LISA function and focuses on the local patterns of spatial correlations between two variables of interest. Figures 7 and 8 below show the LISA cluster map and bivariate local Moran's I scatter chart between percent non-farm proprietors (entrepreneurs) and overall (2012) broadband availability, respectively.

[10] The figures below will focus on the relationship between percent employed in creative class and broadband adoption and percent non-farm proprietors and broadband availability. The comparison between percent creative class and broadband availability and percent non-farm proprietors and broadband adoption can be found in Appendix A.

Figure 7. LISA Map of Percent NFP and Wired Broadband Availability

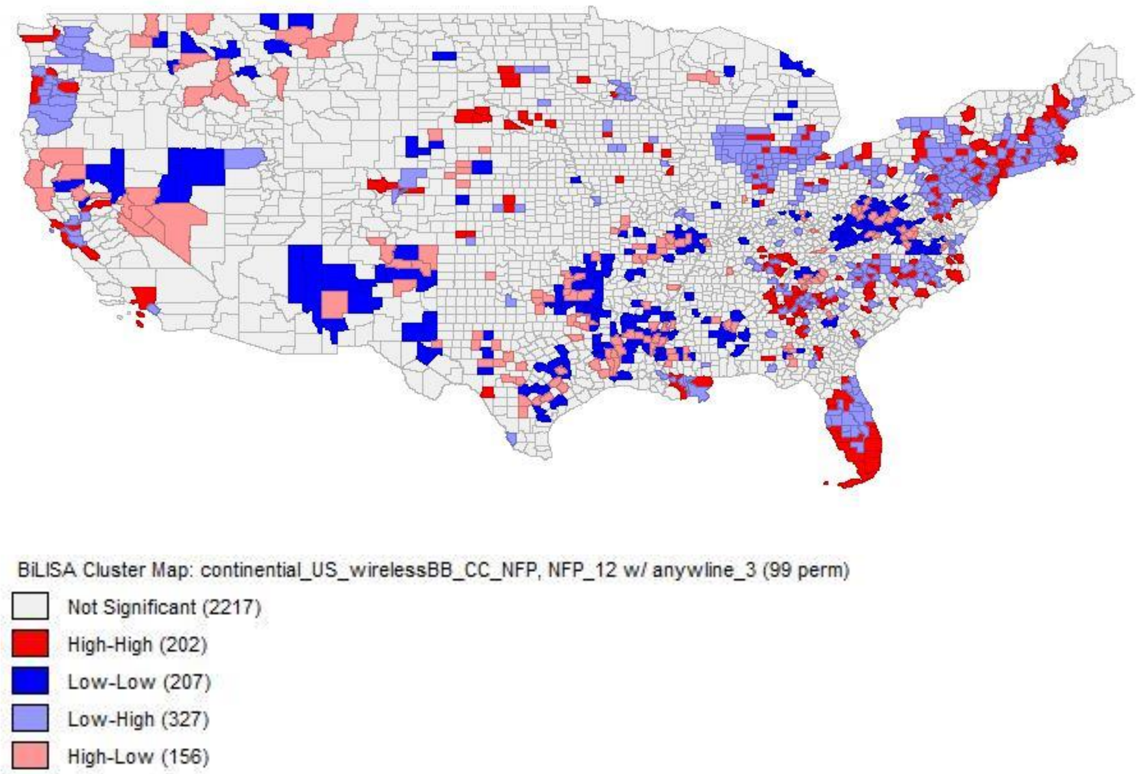
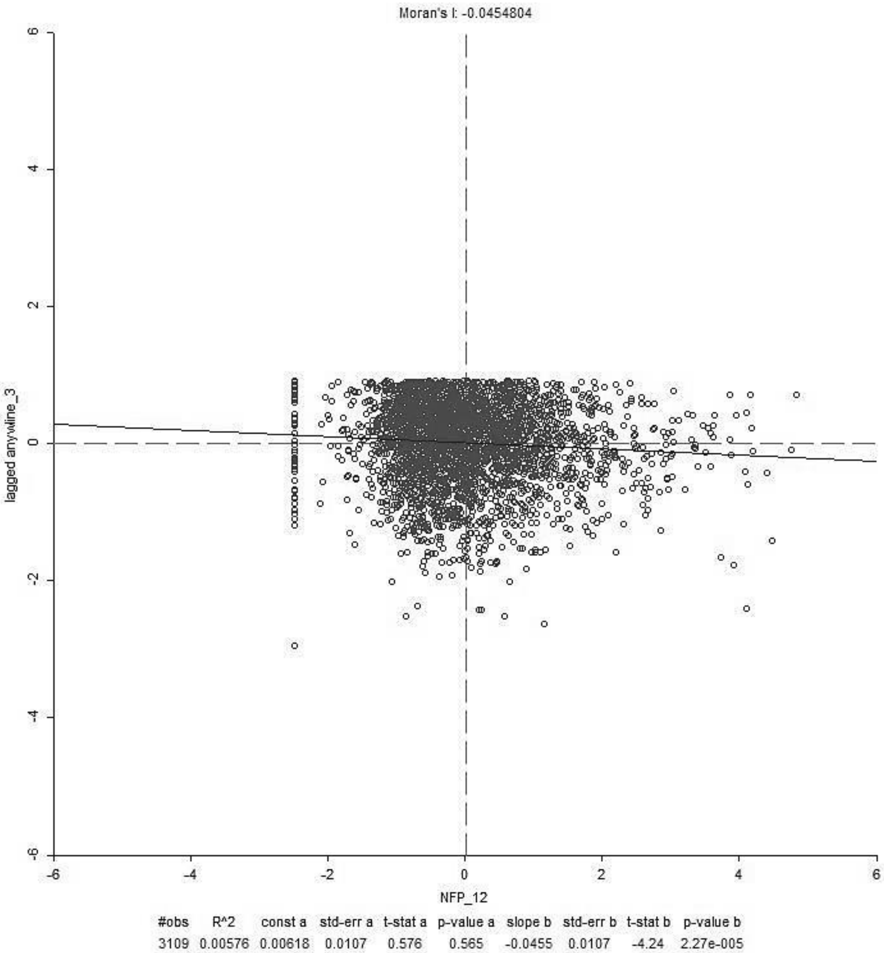


Figure 8. Bivariate Local Moran's I: Percent NFP and Wired Broadband Availability



While the majority of counties are not significant (Figure 7), we can observe both spatial clusters ("High-High" and "Low-Low") and spatial outliers ("High-Low" and "Low-High"). Specifically, the northeast region of the US is characterized by "Low-High" and "High-High" counties. These "Low-High" counties are areas where low percentages of entrepreneurs are surrounded by counties with high overall wired broadband. As one might expect, there are also several clusters of "Low-Low" areas in Appalachia, the south and southwest, where low levels of entrepreneurs are surrounded by low wired broadband availability. The Moran's I = -0.045, and a p-value = 0.000 (Figure 8), signifies a negative and significant relationship exists between entrepreneurs and overall wired broadband availability. This suggests that wired broadband availability may in fact have a negative relationship with entrepreneurs. However, the bivariate LISA does not control for any other factors – which is why spatial regressions are used.

Figures 9 and 10 below show the LISA cluster map and bivariate local Moran's I scatter plot between percent employed in creative class jobs and overall (2011) broadband adoption, respectively.

Figure 9. LISA Map of Percent Employed in Creative Class and Broadband Adoption

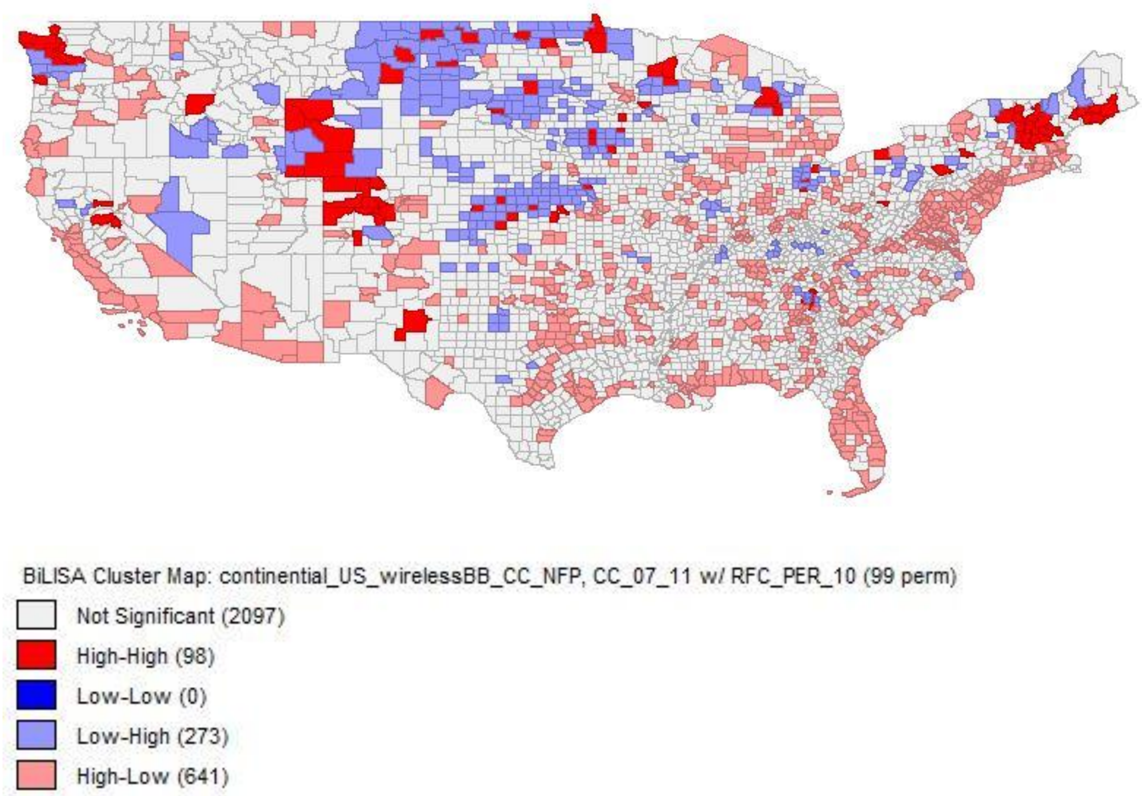
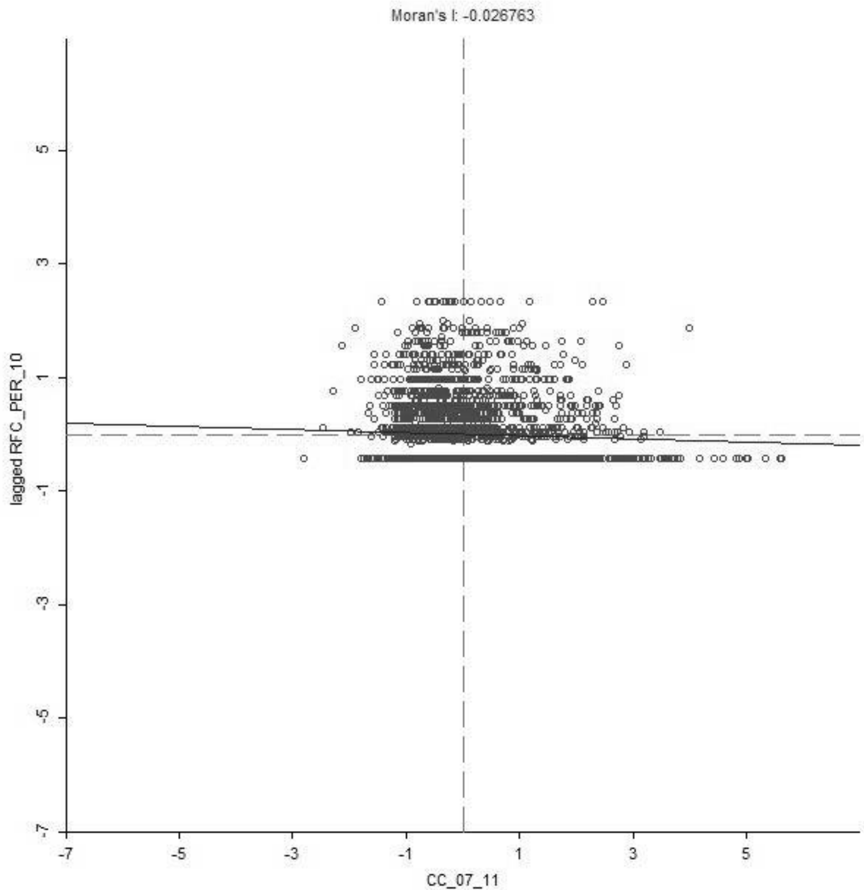


Figure 10. Bivariate Local Moran’s I: Percent Creative Class and Broadband Adoption



#obs	R^2	const a	std-err a	t-stat a	p-value a	slope b	std-err b	t-stat b	p-value b
3109	0.00213	-0.00588	0.0104	-0.565	0.572	-0.0268	0.0104	-2.57	0.0101

When mapped (Figure 9), it is interesting to note that no “Low-Low” clusters are observed. However, as one might expect “High-High” clusters occur in the New England area and around Denver, CO, and above. High levels of creative class workers are surrounded by high levels of overall broadband adoption. This is consistent with the overall broadband adoption map (Figure 3) where very high levels of broadband adoption can be seen in Colorado and in the Northeast.

Interestingly, there are a large number of “High-Low” counties – those with high creative class but surrounded by low broadband adoption. The Moran’s I = -0.027 and is significant (p-value = 0.0101). This suggests that the overall relationship between broadband adoption and creative class employment may in fact be negative.

It is also important to note that these above effects are focused on the overall (continuous or categorical) broadband measures and not the previously defined dummy variables capturing the "high" or "non-metro" effects that will be used in the spatial modeling techniques to follow.

The LISA map and bivariate local Moran's I comparison between percent creative class and broadband availability and percent non-farm proprietors and broadband adoption can be found in Appendix A.

The scatter plots and maps above help establish a presence of spatial autocorrelation between our variables of interest, and suggest spatial modeling techniques are appropriate. Using the decision tree (Figure 6), 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. However, before OLS regressions can be run, a spatial weights matrix, queen contiguity[11], is created so the various Lagrange Multiplier (LM) tests will be available. These tests are used to indicate whether a spatial lag or spatial error model is most appropriate. Once the queen weights matrix is specified, a traditional OLS model can be run using the "classic" button.

For example, to test if a positive relationship exists between wired broadband adoption and entrepreneurship in rural American (H1a), the percent NFP is selected as 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

[11] A queen weights matrix are contiguity-based matrices and defines a location's neighbors as those with either a shared border or vertex (Anselin 2005).

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 (Table 5).

Table 5. Test of Spatial Dependency

Tests	NFP				CC			
	Avail		Adopt		Avail		Adopt	
LM Lag	105.17	***	104.11	***	13.89	***	13.87	***
LM Error	191.62	***	190.80	***	144.17	***	144.56	***
Robust LM Lag	14.49	**	15.17	**	7.33	**	7.38	**
Robust LM Error	100.94	***	101.86	***	137.60	***	138.08	***
Moran's I	14.18	***	14.15	***	12.33	***	12.35	***
Appropriate model	Spatial Error		Spatial Error		Spatial Error		Spatial Error	

, and * represent statically significance at the p = 0.00001 and 0.000001

When examining the output for H1a (broadband adoption and entrepreneurs), the Moran's I value is significant, indicating spatial autocorrelation is present and can be helped by running either a spatial lag or error model. Next, both the LM lag and error test are examined for significance. In this case, both the LM lag and LM error values are significant, therefore the Robust LM lag and error models are examined. The robust LM for the lag model is significant (p-value= 0.0000984), however the robust LM for the error model is highly significant (p-value=0.0000000), indicating the *spatial error* is the best choice.

If both the robust LM lag and error models were significant, both lag and error models can be run and 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 (Table 6). A higher Log-likelihood, lower AIC and lower SC, all indicate the better fitting model (Anselin 2005). For the NFP and creative class models, the goodness of fit diagnostics (Table 6) reinforce the findings of the spatial dependency tests (Table 5) that the spatial error model is more appropriate.

Table 6. Measures of Fit for Lag and Error Models

	NFP		CC	
	Avail	**Adopt**	**Avail**	**Adopt**
Lag				
Log likelihood	3397.58	3388.49	7119.14	7121.54
Akaike info criterion	-6757.16	-6738.97	-14200.3	-14205.10
Schwarz criterion	-6642.36	-6624.18	-14085.5	-14090.30
Error				
Log likelihood	**3437.76**	**3429.533**	**7178.472**	**7181.06**
Akaike info criterion	**-6839.52**	**-6823.07**	**-14320.9**	**-14326.10**
Schwarz criterion	**-6730.77**	**-6714.31**	**-14212.2**	**-14217.40**

However, since the robust LM for the error model is highly significant, the spatial error model is then run in GeoDa. The spatial error model output is then examined and the lambda (spatial parameter) is found to be significant.

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. In each case, the spatial error model was determined to be the most appropriate. A total of eight models are run (four traditional OLS models and four spatial error models).

First-differenced Regression

To evaluate (H4) 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 a specific 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 7 shows a side-by-side comparison of summary data statistics for 2000/2012.

Table 7. 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	***
% 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[12]. A simple OLS 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 as the independent variables (equation specified above).

[12] Broadband is assumed to be zero as of 2000 (Pew Research Center 2015).

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 OLS 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.

CHAPTER IV

RESULTS

This research was fueled by a lack of spatial techniques applied to broadband and rural studies in the existing literature, coupled with the overall lack of focus on broadband and rural entrepreneurship and creative class employment. This overall objective is to assess whether broadband availability/adoption has a meaningful relationship with specific categories of jobs in rural America – and if so, take a first step towards determining which way causality runs.

The first specific objective is to determine whether or not there is a relationship between current levels of entrepreneurship and creative class workers and broadband in rural areas. As the previous chapter highlighted, spatial error models were found to be the most appropriate specification in all instances. In order to test H1a, H1b, H2a, H2b, and H3 (specified in Chapter I), a series of 10 cross-sectional spatial models were run.

Table 8 (below) shows the results from the spatial error model testing the relationship between *wired* broadband adoption and entrepreneurship/ creative class measures in rural America (H1a and H1b). Since this particular research is focused on the impact to rural America, the variables of interest are NMHIADOPT_12, and NMHIADOPT_ 11.

Table 8. 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
NON-METRO	-0.0336	***	0.0049	NON-METRO	-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

It was hypothesized that a positive relationship exists between entrepreneurs (NFP) and broadband adoption in rural America. However, both dummy variables for high broadband adoption overall and for non-metro broadband adoption were found to be negative, but not significant. It is important to note that being in a non-metro county is negatively associated with entrepreneurship, as evidenced by the -0.336 coefficient on the non-metro term. The non-significant coefficient on the non-metro adoption variable suggests that broadband adoption does not change this relationship; however it is still important to note that non-metro areas are still disadvantages. The non-significant broadband parameter indicates that broadband adoption is not as important to entrepreneurs as originally hypothesized. One interpretation of this result is that broadband adoption is not important because the entrepreneurs are not overly concerned with how much others around them are using broadband.

Other results from this model are expected. Unemployment and median household income are found to be positively and significantly related to entrepreneurs. An increase in unemployment leads to people trying to make money on their own as entrepreneurs. Other positive, significant relationships with entrepreneurs include education variables (percent with high school diploma and percent with bachelor’s degree or higher), percent Hispanic, and the percent employed in agriculture. Interestingly, there is also a positive and significant relationship between entrepreneurs and the county-level natural amenity rank. This finding is supported by previous studies that the greater the desirability of the climate, the more entrepreneurs the area will attract (Markeson and Deller 2012).

The percent non-farm proprietors are significantly and negatively related to non-metro counties, meaning there are higher percent of entrepreneurs in metro areas. Entrepreneurs are significantly and negatively related to the percent Asian and percent “other,” along with two age categories (ages 20-60), and overall population.

Shifting our focus to the relationship between broadband adoption and creative class, it was hypothesized that a positive relationship also exists between those employed in creative class jobs and broadband adoption in rural America. 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 *negatively* influenced by broadband adoption. Note, again, that this negative impact of broadband adoption in non-metro counties is added to the negative general result for being in a non-metro country (-0.0045). Thus, the presence of a high percentage of broadband adoption puts non-metro counties at even more of a disadvantage in terms of creative class employees. This may reflect the types of creative class jobs often found in rural areas, for example, farm labor contractors, butchers, and pipe layers.

Other positive and significant relationships with creative class employees include median household income, natural amenity rank, population, bachelor's degree or greater, and those ages 35-60. Interestingly, the younger age group, those ages 20 – 34 are significantly and negatively correlated with the percent creative class, along with non- metro counties, percent black and percent Hispanic.

Table 9 (below) shows the results from the spatial error models examining the relationship between broadband *availability* and entrepreneurship/ creative class employment in rural America. These cross-sectional spatial models were used to test H2a and H2b.

It was hypothesized (H2a) that a positive relationship exists between wired broadband availability and entrepreneurship measures 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 significant. This indicates that while broadband adoption might not be important to rural entrepreneurs (Table 8), having broadband available is positively related. Note, that the non-metro dummy variable itself is still negative (-0.0432) and so this positive result for availability does not completely offset the non-metro disadvantage.

One interpretation of this is that some rural entrepreneurs do need broadband to do their jobs so the availability of it is important to them (Table 9). These entrepreneurs may not care as much about the broadband adoption tendencies of those living near them (Table 8).

Table 9. Spatial Error Regression Results: Wired 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	***	0.002	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	***	0.044	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
NON-METRO	-0.0432	***	0.0067	NON-METRO	-0.0036	*	0.0019
PCTEMPAGRI	0.1659	***	0.0344	PCTEMPAGRI	-0.1214	***	0.0110
HIAVAIL_12	-0.0248	***	0.007	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

Again, other results are as expected. A positive and highly significant relationship is also found between entrepreneurs and unemployment rate, median household income, natural amenities, percent population with high school diploma only, percent population with bachelor's degree or higher and percent employed in agriculture. These positive and significant relationships are also found in Table 8 above.

Similar to the previous entrepreneurship model, a negative and significant relationship can be found between entrepreneurship and population, percent Asian population, percent population "other," two age categories (20 – 34 and 35 – 60), and non-metro counties.

H2b hypothesized that a positive relationship exists between wired broadband availability and creative class employment in rural America. However, when examining the high broadband availability, non-metro dummy variable, a significant, negative relationship is found. Note, the non-metro dummy variable is also negative (-0.0036), which only adds to the disadvantage non-metro areas have in terms of creative class employees. The opposite is true for the general high broadband availability dummy variable. It is found to be positive and significant, indicating broadband availability is positively related to creative class employees, just not specifically in non-metropolitan areas.

Comparable to the previous creative class model, the same variables were found to be positive and significant (median household income, natural amenity rank, population, percent bachelor's degree or higher, and percent within the ages 35 – 60). This is what one might expect, including a positive and significant relationship with the percent with a bachelor's degree or higher, due to the higher education level required by many "creative class" defined occupations.

Wireless broadband connections are different in function and accessibility from wired broadband technologies; therefore, a second objective of this research is to assess whether there is a distinction between wireless and wired broadband availability in the relationship between current levels of entrepreneurship and creative class workers and broadband in rural areas. To test H3, first an OLS regression was run, followed by spatial models (error and lag). Similar to the previous models, the spatial error model was the best fit, and the results can be found in Table 10 below.

Table 10. Spatial Error Regression Results: Wireless Broadband Availability

NFP				CC			
Variables	Coefficient		Standard Errors	Variables	Coefficient		Standard Errors
CONSTANT	0.6172	***	0.1241	CONSTANT	-0.3533	***	0.0374
UR_12	0.5903	***	0.0856	UR_11	0.0400	*	0.0239
LNMHI_12	0.0114		0.0118	LNMHI_11	0.0398	***	0.0036
LNPOP_10	-0.0371	***	0.0020	LNPOP_10	0.0030	***	0.0006
NATAM	0.0117	***	0.0021	NATAM	0.0045	***	0.0006
BLACK_12	-0.0226		0.0159	BLACK_11	-0.0105	**	0.0046
HISP_12	0.0257		0.0184	HISP_11	-0.0087		0.0054
ASIAN_12	0.0729		0.1044	ASIAN_11	0.0373		0.0312
OTHER_12	-0.0921	***	0.0237	OTHER_11	0.0078		0.0071
HSEDU_12	0.1606	***	0.0448	HSEDU_11	-0.0251	*	0.0131
BACH__12	0.1747	***	0.0405	BACH__11	0.4328	***	0.0124
AGE_5_19_12	-0.1108		0.0675	AGE_5_19_11	-0.0319		0.0253
AGE_20_34_12	-0.7970	***	0.0817	AGE_20_34_11	-0.1591	***	0.0272
AGE_35_60_12	-0.2236	***	0.0689	AGE_35_60_11	0.1079	***	0.0253
NON-METRO	-0.0428	***	0.0058	NON-METRO	-0.0029	*	0.0016
PCTEMPAGRI	0.1111	***	0.0349	PCTEMPAGRI	-0.1210	***	0.0101
HIWIRELESS_12	-0.0189	***	0.0061	HIWIRELESS_11	0.0029	*	0.0017
NMHIWIRELESS_12	0.0031		0.0069	NMHIWIRELESS_11	-0.0034	*	0.0020
LAMBDA	0.3634	***	0.0251	LAMBDA	0.3225	***	0.0259
Observations	3109				3109		
R2	0.3908				0.8427		

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

It was hypothesized that there would not be a statistically significant relationship between wireless broadband availability and either entrepreneurship measures/ creative class employment in rural America. While no statistically significant relationship was found between wireless broadband availability and *entrepreneurship* measures for non-metro areas, a negative and significant relationship was found between the percent employed in *creative class* and “high” wireless availability in rural areas.

There was not a significant relationship between non-metro high wireless availability and the percent non-farm proprietors. While that relationship was positive, but not significant, it is important to note the non-metro dummy variable itself was negative (-0.0428). This suggests that overall being a non-metro county is negatively associated with entrepreneurship. A negative and significant relationship is found in the overall high wireless availability measure. This may be driven by highly urban counties with nearly 100 percent wireless access across their populations, but relatively fewer entrepreneurs.

Other negative and significant relationships with entrepreneurship measures include population, “other” race category, and two age categories (ages 20 – 60).

Shifting over to the relationship between percent employed in creative class and high wireless broadband interestingly, there is a positive and significant coefficient for all counties and a negative and significant relationship for non-metro counties. Unemployment rate, natural amenities rating, percent with a high school diploma, percent with a bachelor’s degree or higher, and the percent employed in agriculture are all also positively and significantly related to entrepreneurs. These findings are consistent with the other entrepreneurship models.

When it comes to the relationship between the percent employed in creative class industries and high wireless broadband availability, the exact opposite is found. A significant and negative relationship is found in non-metro counties, while there is a positive and significant relationship in all counties. In rural areas a high wireless connection does not have a positive influence on creative class individuals. Note, that the non-metro dummy variable is also negative (-0.0029), which further adds to the fact that simply being a non-metro county has an overall negative relationship with the percent employed in creative class.

The relationship with the other explanatory variables and percent employed in creative class industries are overall very similar. As expected, the relationship between percent with a bachelor’s degree or higher and creative class employees is positive and highly significant across all three models.

It is also important to note that the spatial error parameter (lambda) in all six spatial error models above exhibited positive and significant values, signifying the spatial error models are superior to traditional OLS models.

These cross-section spatial regressions are a good indicator at what is happening during a specific snapshot in time – namely 2011 and 2012. However, some may argue that 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?

The third objective of this research is to determine whether the relationship between broadband adoption/ availability and entrepreneurship and creative class is a causal one, and if so, in which direction causality runs. While strict causality is not able to be determined with the methodologies used in this analysis, first-difference regressions are used to help make preliminary claims regarding causality. Tables 11 and 12 show the results from the first-differenced regressions.

It was hypothesized there would not be a causal relationship between broadband availability/ adoption and entrepreneurship and creative class employment in rural America. Note that these regressions are run only on non-metro counties (and hence have a lower number of observations).

Table 11. First-differenced Regression: Broadband Adoption, NFP and Creative Class

	Δ NFP		Δ Creative Class	
Δ BBADOPT	-0.0096	***	-0.0023	***
Δ UR	0.6406	***	0.0158	
Δ LNMHI	0.0187	***	0.0085	***
Δ LNPOP	-0.1329	***	0.0104	
Race / Ethnicity				
Δ WHITE	-0.1279		0.0168	
Δ BLACK	-0.3295		-0.1211	
Δ HISP	0.1422		-0.0559	*
Δ ASIAN	-0.0156		-0.1353	
Δ OTHER	-0.2698		0.0190	
Education				
Δ HSEDU	0.1776	***	-0.0596	***
Δ BACH +	0.1081		0.1145	**
Age				
Δ AGE 5-19	0.9841	***	0.0578	
Δ AGE 20-34	0.7289	***	0.0171	
Δ AGE 35-59	0.4916	**	0.0152	
Δ AGE 60+	0.9060	***	0.0491	
Constant	0.0420	**	0.0155	***
Observations	1931		1949	
R2	0.1936		0.0433	

*,**, 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. This implies that as counties increased their broadband adoption rates, the percent of entrepreneurs actually fell overtime. This counterintuitive result may suggest that non-farm proprietors are in fact decreasing as broadband adoption becomes more prevalent – perhaps due to jobs in other industries.

The change in creative class employees from 2000 to 2007-11 is also found to be negative and significantly correlated with the change in broadband adoption in non-metro counties. This suggests that over time broadband adoption is not important to those in creative class fields, which supports the findings in the spatial models when only a snap-shot of time was examined. Note, however, that the R^2 is significantly lower for the creative class model.

Table 12 outlines the first-differenced regression results between broadband *availability* and entrepreneurs and creative class workers. The relationship between entrepreneurship and creative class employees and non-metro broadband availability over time (2000-2012) is found to be negative and significant in rural areas.

When the other explanatory variables are examined overtime, they have relationships one would expect and that are observable in the previously laid out spatial models. For example, increases to the unemployment rate over time are positively (and significantly) related to entrepreneurs and increasing the percentage with a bachelor's degree or higher is positively (and significantly) related to the percent of creative class employees' over time.

Table 12. First-differenced Regression: Broadband Availability, NFP and Creative Class

	Δ NFP		Δ Creative Class	
Δ BBAVAIL	-0.0627	***	-0.0073	*
Δ UR	0.6777	***	0.0246	
Δ LNMHI	0.0129	*	0.0074	**
Δ LNPOP	-0.1319	***	0.0091	
Race / Ethnicity				
Δ WHITE	-0.3142		-0.0145	
Δ BLACK	-0.5246		-0.1533	
Δ HISP	0.1309		-0.0577	*
Δ ASIAN	-0.2329		-0.1825	
Δ OTHER	-0.4730		-0.0147	
Education				
Δ HSEDU	0.1825	***	-0.0543	**
Δ BACH +	0.0972		0.1095	**
Age				
Δ AGE 5-19	1.0245	***	0.0727	
Δ AGE 20-34	0.7216	***	0.0209	
Δ AGE 35-59	0.5201	**	0.0253	
Δ AGE 60+	0.8921	***	0.0520	
Constant	0.0654	***	0.0150	***
Observations	1931		1949	
R2	0.1993		0.0413	

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

The main objective of this research is to improve the understanding of the relationship between broadband and levels of creative class employment and entrepreneurship across *rural* America – and if so, take the first step towards determining which way causality runs. Table 13 summarizes the overall rural findings.

Table 13. Non-Metro Summary Results

	NFP	CC
Spatial Error Models		
BB Adoption	-0.0020	-0.0057***
Wired BB Availability	0.0127*	-0.0046**
Wireless BB Availability	0.0031	-0.0034*
First-differenced Regressions		
BB Adopt Overtime (2000-2011)		-0.0023***
BB Adopt Overtime (2000-2012)	-0.0096***	
BB Availability Overtime (2000-2011)		-0.0073*
BB Availability Overtime (2000-2012)	-0.0627***	

High broadband availability (wired) is found to be positively correlated with the number of entrepreneurs during a specific point in time in rural areas, however overtime broadband availability is found to be negative and significantly related.

While the relationship between entrepreneurs and broadband isn't necessarily cut and dry, the relationship between the percent employed in creative class occupations across all broadband categories are found to be negative and statistically significant in rural America.

CHAPTER V

SUMMARY AND CONCLUSIONS

This research is the first of its kind to examine the role that access to adoption of broadband has on the willingness of creative class individuals to locate in rural areas. One particular improvement to this realm of analysis is the inclusion of spatial techniques when observing these relationships. Utilizing cross-sectional spatial models and recent broadband data, wired broadband availability is found to be important to entrepreneurs in rural areas. The opposite is true for creative class employees in rural areas – the findings suggest that broadband adoption, and wired/ wireless availability actually has a negative influence.

Recently, studies have moved beyond correlation and aimed at determining if there is a causal relationship; therefore, first-differenced regressions were used as a first step towards a causal relationship[13]. The results indicate that over time, broadband availability/ adoption are in fact negatively associated with both entrepreneur and creative class employee growth in rural areas.

Overall, rural America is characterized as having fewer residents with access to high-speed Internet. Many policies have been passed with the goal of bridging the rural-urban

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[13] These models allow for some preliminary claims regarding causality, endogeneity is still a concern, since the direction of the relationship is still undetermined.

broadband gap. Specifically, the Connect America Fund passed in 2014 dedicated $115 million of public funding along with tens of millions more in private investment to improve the broadband infrastructure in rural communities (FCC 2014). This policy, and preceding policies, has focused heavily on increasing the infrastructure (availability) of broadband as opposed to increasing broadband adoption. When it comes to entrepreneurs in rural areas, this research suggest these policies might be a step in the right direction. Adoption was found to be negatively associated across all models, where availability was found to be positive in most cases.

This analysis suggests two very different relationships between broadband availability/ access and entrepreneurs and creative class employees in rural America.

In 2012, wired broadband availability in rural areas is important to entrepreneurs. Interestingly, from 2000 to 2012, increases in broadband adoption and availability were negatively correlated with entrepreneurs in non-metro counties. One explanation is that over time, entrepreneurs were not aware of how broadband could be beneficial to their businesses. Also, entrepreneurs located in rural areas may not even be involved in industries where "high" broadband access/ adoption prove to be beneficial. Conversely, if broadband technologies were found to be beneficial to specific entrepreneurial businesses, they may choose to out-migrate to areas where broadband is available (LaRose et al. 2008). Fast-forward to 2012 where high-speed Internet has largely changed the way many industries and companies conduct business. It is possible that entrepreneurs in rural areas are discovering new opportunities that "high" wired broadband availability would allow them, thus making it important now, and potentially in the future as well. Broadband availability may also be important to rural entrepreneurs because they may need it to do their jobs, while local rates of broadband adoption are not as important because the entrepreneurs are not overly concerned with how much others around them are using broadband.

On the other hand, broadband availability (wired and wireless) and broadband adoption seem to be negatively associated with creative class employees in rural America. Over time, 2000 to 2011, increases in broadband availability also display a negative influence. Creative class employees by definition are those who develop, design, or create new applications, ideas, relationships, systems, or products, including artistic contributions (USDA-ERS 2014). It is possible those involved in those vocations and living in rural areas knew when they moved there 'high" broadband was not going to be available, therefore recognizing that broadband availability is not something that is important to them. Also, it is possible that the type of creative class employees in non-metro counties may be more slanted towards those that might not need broadband – for instance certain types of artists.

From a rural development standpoint, it is important to keep in mind that the overall "high" broadband availability (wired/wireless) and adoption variable has a significant and positive relationship with the percent creative class (Tables 8, 9, and 10). This suggests that for the overall economy, broadband does matter to creative class employees – just not those who reside in rural areas. Increasing broadband infrastructure may be an important step for rural communities to attract and increase their "creative" presence by luring in creative class employees from metro areas.

Another particularly interesting result is the positive and significant relationship between a high natural amenity score and entrepreneurs and creative class employees. With an increase in amenity score[14] there is an associated increase in entrepreneurs and creative class employees. While this relationship was not specifically examined for rural areas, it is a variable that was positive and significant in all equations.

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[14] "The natural amenities scale is a measure of the physical characteristics of a county area that enhance the location as a place to live. The scale was constructed by combining six measures of climate, topography, and water area that reflect environmental qualities most people prefer. These measures are warm winter, winter sun, temperate summer, low summer humidity, topographic variation, and water area." (USDA-ERS 2012)

These findings open the door for other research to be done on the relationship between broadband measures in rural America and entrepreneurs and creative class employees. Recently, the FCC changed the definition of broadband by raising download and upload speed thresholds. Previously defined as 4Mbps download and 1Mbps upload, broadband is now defined as 25Mbps download and 3Mbps upload. Increasing the threshold therefore increases the number of Americans 'without' broadband access, especially in rural areas. This new definition of broadband invites new research to be done on the role broadband availability/ access has on rural America. Further research could also specifically examine rural business broadband adoption as opposed to household adoption.

While the aforementioned first-differenced regressions are a first step towards establishing a causal relationship, the direction of the relationship is still undetermined. It could very well be the case that the lack of an increase in creative class employees or entrepreneurs was actually responsible for some higher growth in broadband availability – perhaps the providers do not see these categories as heavy broadband users. These types of questions likely require alternative approaches such as structural equations modeling or propensity score matching. They also likely require detailed surveys specifically focused on creative class employees and entrepreneurs.

While many fruitful avenues for future research still exist, this analysis has taken a first step in determining the relationship between rural broadband and creative class employees/ entrepreneurs. The results suggest that the direction of influence is not always positive, which is of itself an interesting finding and one that should be taken into account as specific rural development policies are developed.

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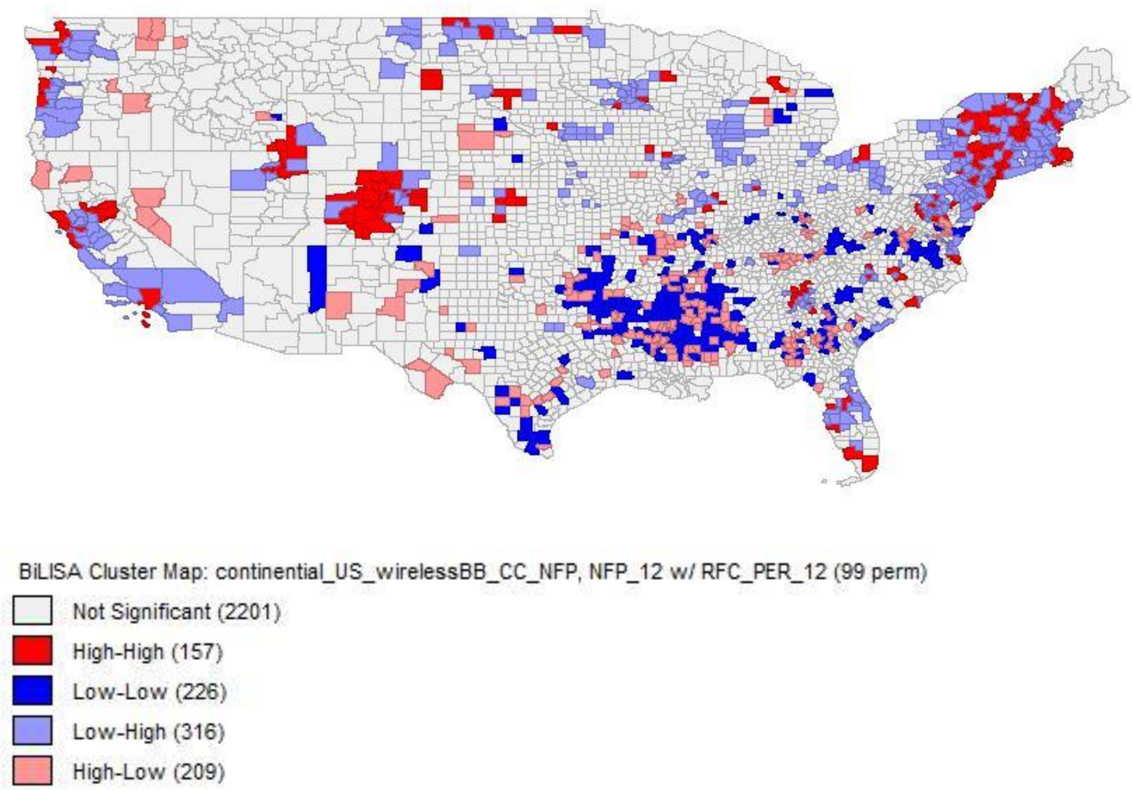
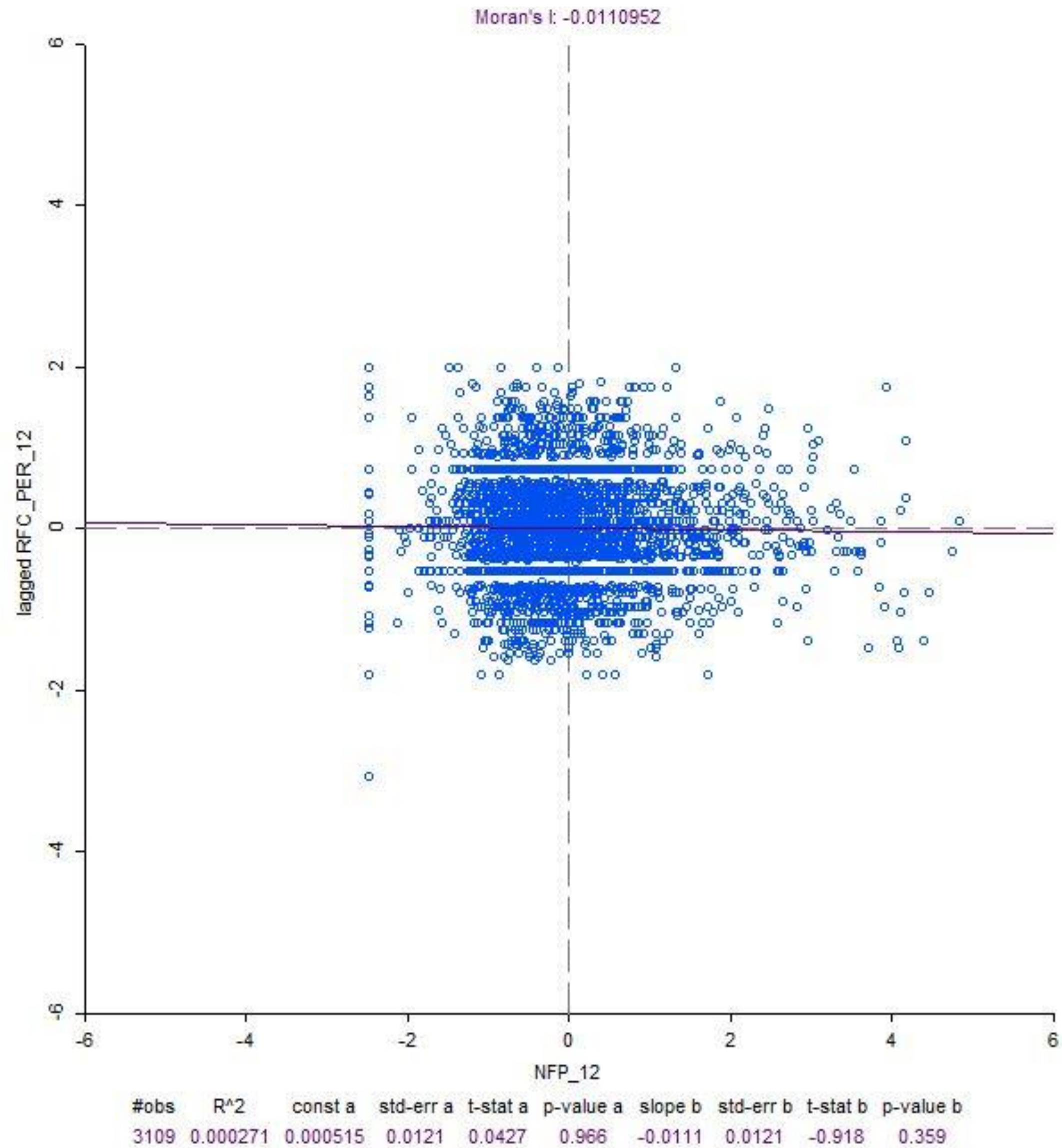
APPENDICES

Appendix A.

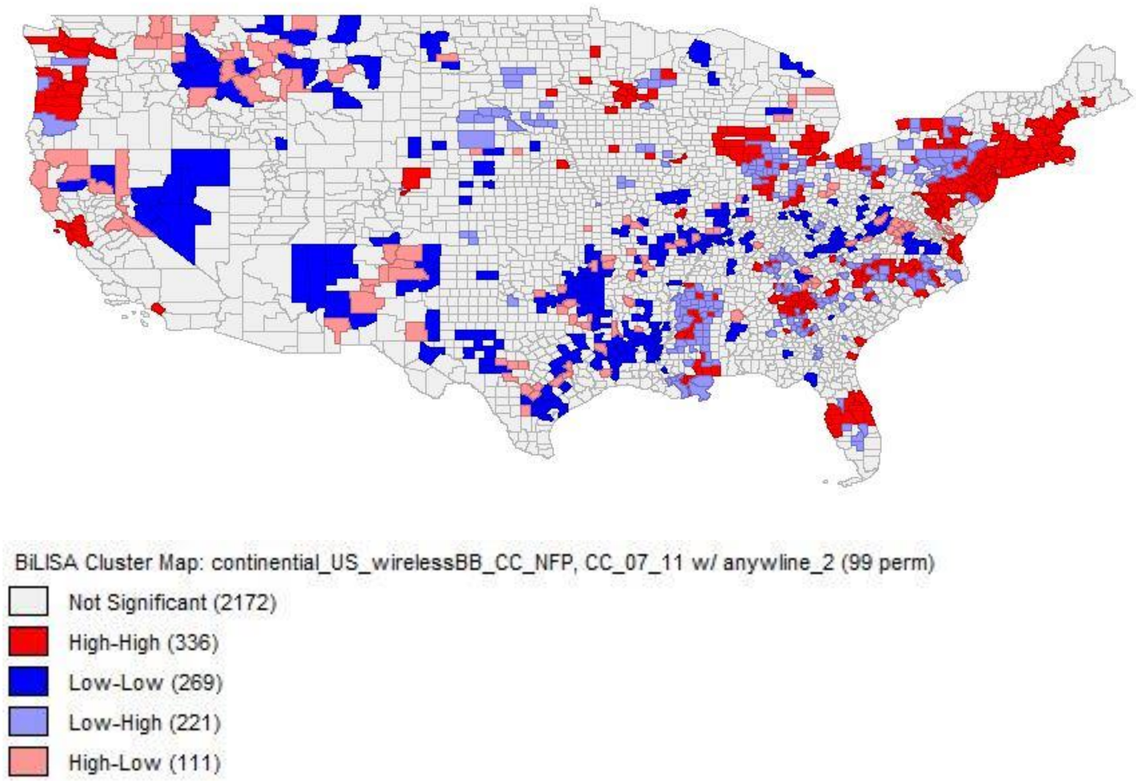
LISA Map of Percent NFP and Broadband Adoption



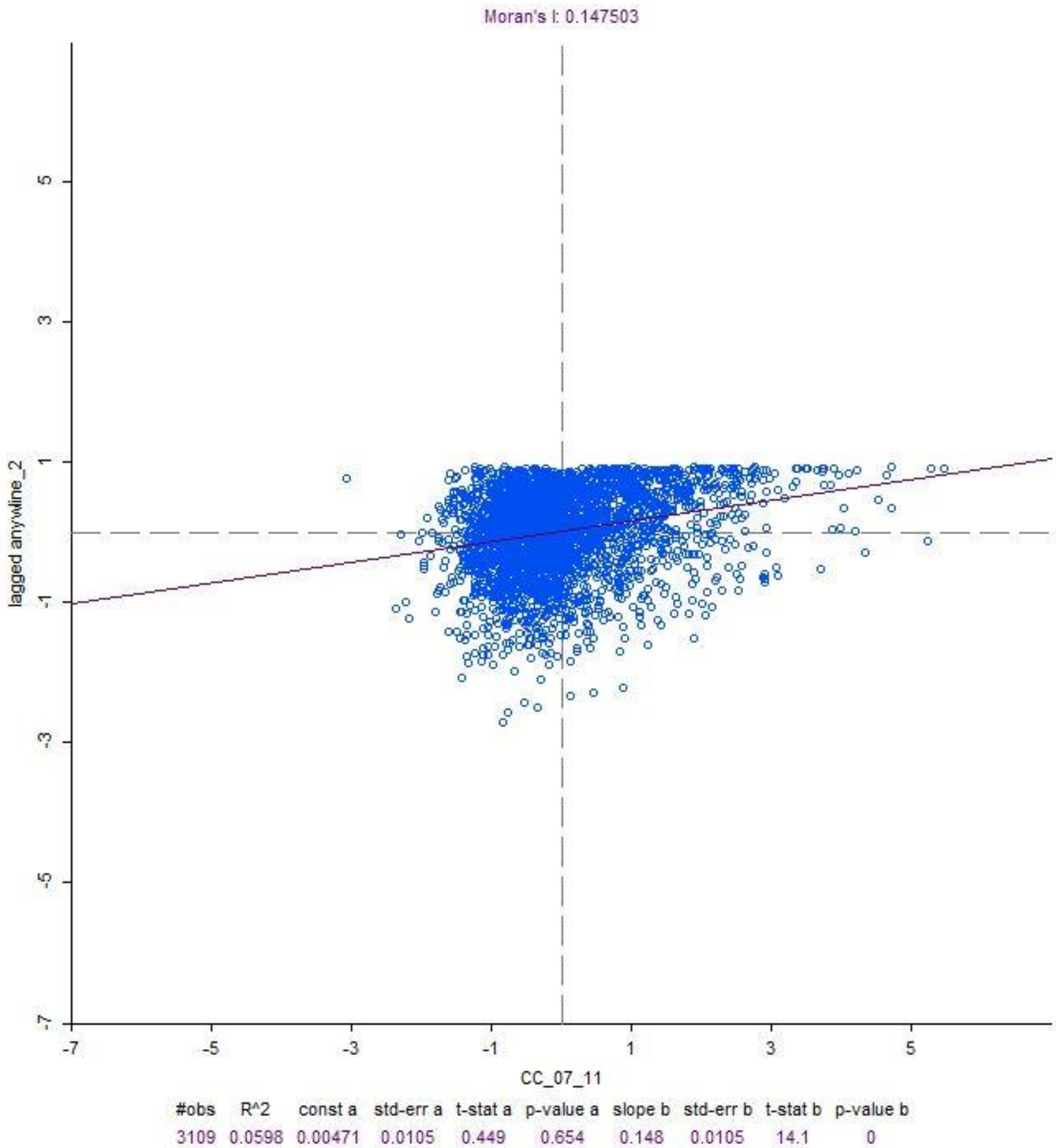
Bivariate Local Moran's I: Percent NFP and Broadband Adoption



LISA Map of Percent Creative Class and Wired Broadband Availability



Bivariate Local Morna's I: Percent Creative Class and Wired Broadband Availability



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