Innovative Activity in Rural Areas: The Importance of Local and Regional Characteristics

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Innovation, supported by a developed and active entrepreneurial system, long has been recognized as critical to regional economic competitiveness.[1] According to Porter (1990, 1996, 1998), regional competitiveness is driven by gains in productivity, and advances in productivity result from sustained innovative activity. Innovation also plays an essential role for rural economic development as these regions respond to the challenges of competing in the global economy. Specifically, Drabenstott and Henderson (2006) propose two key ingredients to a rural development strategy: (1) the twin force of innovation and entrepreneurs, and (2) a critical mass of human, financial, and social capital to support the evolving innovative and entrepreneurial activity.[2] Empirical support for the role of innovation in regional economic growth is provided in a study of county-level differences in 2002 per capita incomes and 1997 to 2002 per capita income growth (Schunk, Woodward, and Hefner, 2005). The authors used county-level utility patents and university research and development expenditures as measures of local innovation and innovative capacity. Their findings indicate that "roughly two-thirds of the variation in county-level per capita income across the U.S. can be explained by variations in these measures of innovation and innovative capacity" (9), and "counties with higher levels of patents and university research and development also appear to see faster rates of growth" (11).

The innovation–economic development relationship is good economic news for regions with significant innovative capacity (such as the Research Triangle in North Carolina) or the resources to attract a major research and development center (Florida and the Scripps Institute, for example). Unfortunately for many local economies, however, innovative capacity and activity are distributed very unevenly across the country. For example, among the 1,343 counties in the thirteen southern states, twenty-six counties averaged 100 or more utility patents a year from 1990 to 1999, while 681 counties averaged less than one utility patent per year for the same period. A clustering of patenting activity would not necessarily be detrimental to the economic development prospects of areas with little innovative activity if there exists the spillovers of jobs and income from the innovation centers to other areas. Evidence of such spillovers is relatively limited. Acs (2002, 165) concluded that "we have established a striking correlation between local R&D and subsequent high-technology employment in the same MSA (metropolitan statistical area) and three-digit industry cluster. There is apparently no spillover relationship from R&D in other industry groups." These findings were duplicated by Shapira (2004), who noted that Georgia's innovation and technology development initiatives had little "trickle-down" impact outside the Atlanta metropolitan region. Finally, Barkley, Henry, and Nair (2004) found a strong correlation between local indicators of innovation and innovative capacity and measures of economic growth and development for metropolitan areas in the South. Little of the metropolitan growth spilled over to proximate nonmetro counties. Nonmetro county employment growth was positively associated with innovative activity in nearby metro areas only if the metro area was a highly active center of innovation and entrepreneurship.

The absence of strong and widespread spillover effects from metropolitan clusters of innovative activity may contribute to a divergence of economic development trends between metropolitan and rural areas. Yet many nonmetropolitan counties have a history of innovative activity, and this base of innovation may serve as the foundation for an endogenous development strategy for these areas. The goal of this research is to identify the local and regional characteristics associated with innovative activity in nonmetropolitan counties in the South. Innovative activity will be measured by utility patent counts for the ten-year period 1990 through 1999. Of special interest are the determinants of innovation in nonmetropolitan counties near metropolitan clusters of innovation. Specifically, is patenting activity in nonmetro counties associated with activity in the metro core, and, if so, what characteristics of rural counties contribute to increased innovation?

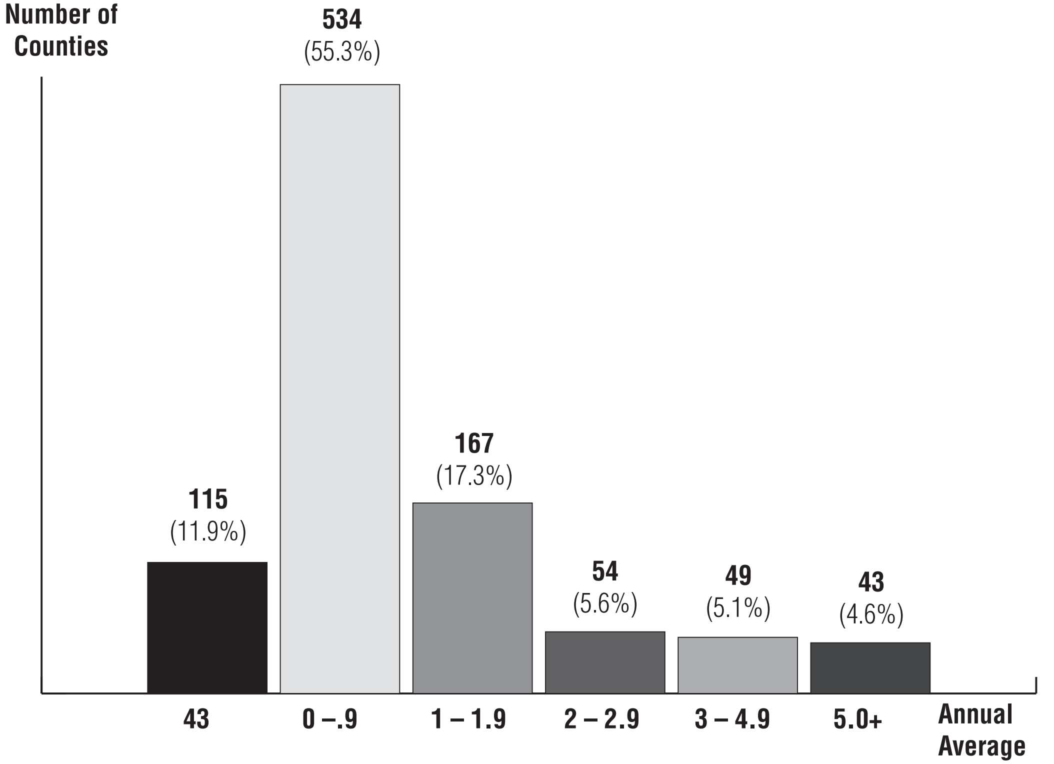
In this article, we provide an overview of innovative activity in the metro and nonmetro South from 1990 to 1999. A statistical indicator of spatial association (the Local Moran I) is used to identify the cores of clusters of innovation among southern counties. Next, we estimate knowledge production functions for the nonmetropolitan counties in labor market areas with a metropolitan core to determine the influence of local and regional characteristics on innovative activity in the nonmetro counties. Our findings indicate that innovative activity is strongest in nonmetro counties with a skilled and technical labor force, diverse industrial structure, natural amenities, a relatively large number of small or large establishments, and innovative activity in nearby counties. Innovative activity in metropolitan areas had only a small impact on rural innovation. The findings for southern nonmetro counties suggest that policies promoting innovation and an entrepreneurial support system offer the potential for employment and income growth in small towns and rural areas. Alternatively, investments in research and development in metro areas provide little benefit to rural areas because the associated spillovers of innovative and economic activity are spatially limited.

Patents as Proxy for Innovation. Previous measures of the innovative process in a region generally focused on: (1) inputs into the process such as public and private expenditures for research and development or employment in scientific and technical occupations; (2) an intermediate output measure such as patents; or (3) proxy measures for innovative output and capacity as reflected in employment in high technology and information technology industries, new product development as reflected in trade and technical publications, or venture capital funding for new enterprises (Barkley, Henry, and Nair, 2006). Among these alternatives, patents have become a popular measure for innovative activity at the local level (for example, county or metropolitan area) because annual data are readily available from the

U.S. Patent and Trademark Office. Alternatively, innovation measures such as new products, private research and development expenditures, and venture capital funding are not available for many nonmetropolitan counties because of data collection costs or data disclosure regulations.

Patent counts are not without shortcomings when used to represent innovation. First, all inventions are not patented, and all patented inventions are not of equal consequence with respect to new products or production processes (Griliches, 1984).[3] Second, Zucker and Darby (2006) claim that the key to new high-technology industries is the presence of "star scientists" and not the scientists' "disembodied discoveries." The authors note that patents tend to diffuse over time, while the science and engineering stars become more concentrated. Third, patenting activity is concentrated in manufacturing. Innovative activities in trade and service industries are less likely to be patented, and the use of patent data may overrepresent the relative innovative activity of counties with significant manufacturing sectors. Finally, patents are credited to the home address of the lead scientist on the patent. This location may not be the same county where the research and development occurred or where the new product/process was implemented. Acs, Anselin, and Varga (2000) recognize the shortcomings

Figure 1. Distribution of Patenting Activity Among Southern Nonmetropolitan Counties, 1990-1999



of patent data, but their research finds a reasonably high (.79) correlation between patent and SBA innovation counts at the metropolitan level, plus patent and innovation counts are associated in a similar manner to explanatory variables included in regional knowledge production functions. The authors conclude that “the empirical evidence suggests that patents provide a fairly reliable measure of innovative activity” (28).

Table 1. Southern Nonmetropolitan Counties That Averaged More Than 10 Patents per Year, 1990–99

County	State	Patents 1990–99
Washington	Oklahoma	554
Stephens	Oklahoma	480
Montgomery	Virginia	327
Hall	Georgia	193
Roane	Tennessee	188
Henderson	North Carolina	174
Iredell	North Carolina	148
Indian River	Florida	145
Payne	Oklahoma	143
Franklin	Texas	128
Bradley	Tennessee	127
Kay	Oklahoma	121
Monroe	Florida	113
Kleberg	Texas	108
Oktibbeha	Mississippi	107
Oconee	South Carolina	105
Beaufort	South Carolina	104

Patents 1990–99. The innovative activity in southern nonmetropolitan counties (as reflected in utility patents 1990–99) varied markedly across the 965 counties (1990 nonmetro designation). For example, 115 nonmetro counties (11.9 percent) reported no patents for the ten-year period (see Figure 1). Another 534 counties (55.3 percent) averaged less than one patent per year for the time period. In sum, over two-thirds (67.2 percent) of the southern nonmetropolitan counties had fewer than ten patents over the ten-year period. Alternatively, a relatively small number of nonmetro counties were very active in innovation. Seventeen nonmetro counties (Table 1) averaged more than ten patents per year from 1990 to 1999. These seventeen counties accounted for 3,255 patents or 25.7 percent of all patenting activity among the 965 southern nonmetro counties. Among the most innovative nonmetropolitan areas are counties with major research universities (Oktibbeha, Mississippi, and Payne, Oklahoma); counties near major federal research centers (Roane, Tennessee, and Indian River, Florida); counties with large employment in the oil industry (Washington and Stephens, Oklahoma): and counties near metropolitan areas (Hall, Georgia, and Bradley, Tennessee).

Metropolitan areas, as expected, had significantly more patenting activity than nonmetro counties (Table 2). The average metropolitan county had 287.4 patents from 1990 to 1999 for an average of 18.7 patents per 10,000 residents. Nonmetro counties averaged only a total of 13.1 patents and 5.1 patents per 10,000 population. Proximity to a metro area did not necessarily result in greater patenting activity for the nonmetro county. The average number of patents (13) and patents per 10,000 residents (5) were almost identical for the 591 nonmetro counties in Labor Market Areas (LMAs) with a metro core versus the 374 nonmetro counties in LMAs consisting entirely of nonmetro counties.[4]

Table 2. Mean Values of Patenting Activity 1990–99 by County Type, Selected Counties

County Type	Mean Total	Mean Patents per 10,000 Population
Metropolitan (393)a	287.4	18.7
Nonmetropolitan (965)	13.1	5.1
Nonmetro Subgroups		
Metro LMA (591)	13.1	5.1
Nonmetro LMA (374)	13.0	5.1
Regional Innovation Systems Nonmetro Subgroups		
Outliers (31)	16.7	6.2
High (44)	19.3	7.4
College Towns (24)	7.1	3.9
Medium (135)	15.2	5.2
Below Average (320)	10.7	4.4
Low (36)	18.1	8.2

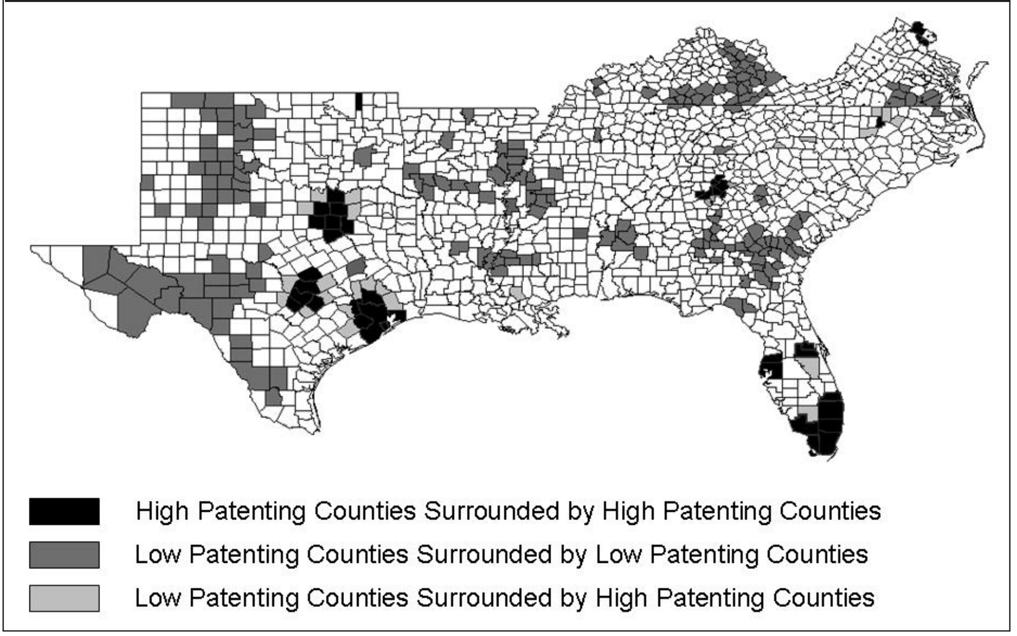
(a) *Number of southern counties in the category*

Spatial Concentrations. Previous research indicates that innovative activity is positively associated with the availability of industry clusters and the business services and entrepreneurial environment provided in urban areas (see, for example, Gordon and McCann, 2005, and Anderson, Quigley, and Wilhelmsson, 2005). In addition, the existence of limited geographic spillovers from innovative activity (Acs, 2002) suggests that patenting activity will remain clustered in these locations with significant R&D inputs and supportive environments. Of particular interest to this study are the identification clusters of innovation in the South and the participation of nonmetro areas in these clusters.

Multi-county clusters of innovative activity were identified using the Local Moran I as the local indicator of spatial association (LISA).[5] Figure 2 provides the counties identified as clusters of high innovative activity and clusters of little or no patenting activity. Clusters of high patenting activity (46 counties) are evident in Texas (Houston, Austin, and Dallas); Atlanta; South Florida; Raleigh–Durham, North Carolina; Northern Virginia; and Washington County, Oklahoma (home of Conoco/Phillips Petroleum). All but three of the

Figure 2

Multi-Country Clusters of High and Low Patenting Activity, 1990 – 1999

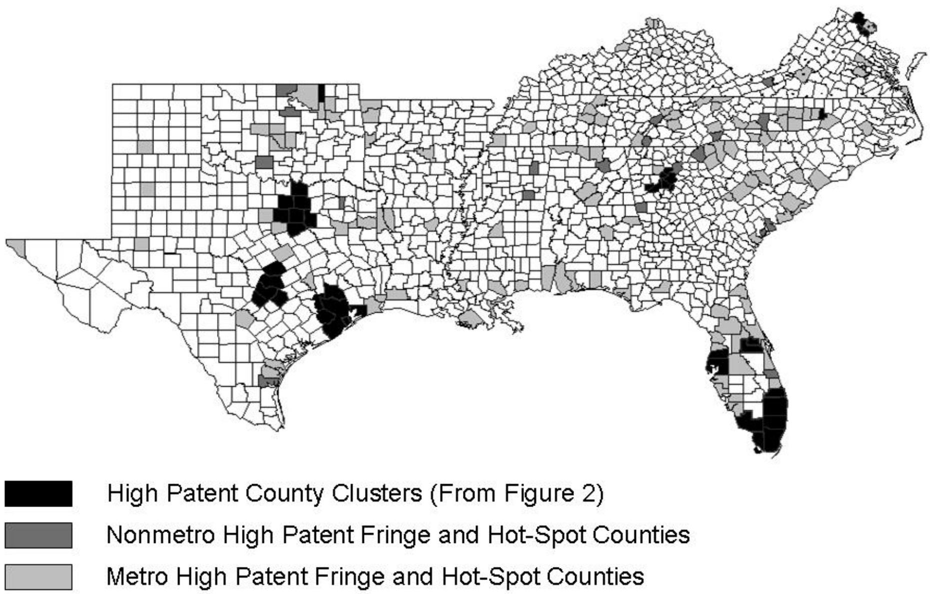


forty-six counties in the "high-innovation" clusters are metro counties. Also evident in Figure 2 are numerous clusters of low innovative activity. These agglomerations of counties with few patents occur in Appalachian Kentucky, the Mississippi Delta, the Deep South Cotton Belt, and Western Texas and Oklahoma. The low-innovation clusters are dominated by nonmetro counties.

The LISA clusters of high total patents may understate innovative activity in the South because the Local Moran I identifies only the cores of the clusters of innovation. Missing from Figure 2 are the fringe counties to the clusters of innovation, counties that have high-patent values but lack high-patent neighbors in most directions. Also missing are "hot spots" of patenting activity. These "hot spot" counties have high total patents, but the patenting activity in their neighboring counties is insufficient for inclusion as a core in a cluster of innovation. To help identify the "fringe" and "hot spot" counties, we add all counties with eighty-nine or more patents from 1990 to 1999 (89 is the fewest number of patents for a county included in a high-high cluster). We identified 150 additional counties using the modified selection criteria–18 nonmetro and 132 metro counties (Figure 3). Some of these 150 counties are fringe counties of the clusters of innovation, especially in the case of Florida and the Raleigh–Durham area of North Carolina. In general, however, the additional counties represent "hot spots"–counties with high patent totals surrounded by counties with a mix of patenting activity. These areas may represent "emerging" clusters of innovation if spillovers to nearby counties are significant.

Figure 3

High Patenting Areas: Cluster, Fringe Counties and Hot Spots, 1990 – 1999



In summary, 195 southern counties are identified as members of high-innovation clusters, high-innovation fringe counties to these clusters, or innovation "hot spots." Only 21 of the 195 counties are nonmetropolitan counties, thus, the urban-rural economic gap in the South will continue to widen unless rural areas can generate more innovations and the entrepreneurial support system to convert these innovations to jobs and income. The following discussion addresses the local and regional characteristics associated with an environment conductive to innovative activity.

County Characteristics Related to Innovative Activity

Regional Knowledge Production. Griliches (1979) and others developed the concept of a regional knowledge-production function to help identify factors contributing to an area's innovative activity.[6] This function assumes that output from the innovative process is the result of inputs into the process (for example, industry and university R&D) and local characteristics supportive of innovation and the spread of innovative activity throughout the regional economy (industrial structure and characteristics of the local labor market).

The regional knowledge production function may be expressed as:

$$(1)\ I = f(PR, UR, Z1\ldots, Zn)$$

where *I* measures innovation output, *PR* is private industry R&D, *UR* is university R&D, and Z1 to Zn represent county and regional characteristics relevant to the local innovative and entrepreneurial environment. The proxy variable selected for PR is the percent of county employment in scientific and technical occupations, and the proxy measure for UR is the number of individuals in the county enrolled in college.[7] County and regional characteristics found in earlier research to be associated with innovative activity are (a) employment in high-tech industries (Riddel and Schwer, 2003); (b) size, structure, and diversity of the local economy (Anderson, Quigley, and Wilhelmsson, 2005); (c) education and skills of the local labor force; (d) proportion of small and large firms in the area (Gordon and McCann, 2005); and (e) the presence of innovative activity in nearby locations (Lim, 2004; Acs, 2002).

Table 3. Summary of Estimated Relationships Between Nonmetro County Patent Totals and Local and Regional Characteristics

	Alternative Measures of Metropolitan Innovative Activity in the Nonmetro County's Labor Market Area		
Nonmetro County and Regional Characteristics	Patents, 1990–99	University Research Expenditures	Percent of Employment in Scientific and Technical Occupations
% Manufacturing	NSa	NS	NS
% High-Tech Emp	NS	NS	NS
Total Employment	+b	+	+
Distance to MSA	-c	-	-
% Science and Tech Occ	+	+	+
College Enrollment	NS	NS	NS
Industrial Diversity	+	+	+
Small Establishments	+	+	+
Large Establishments	+	+	+
Amenities	+	+	+
Regional Patent Total	+	+	+
MSA Patent Total	+		
MSA Univ. R&D		NS	
MSA Science and Tech Occ			NS

Source: Lee (2006).
a Relationship between county characteristic patent total was not statistically significant.
b Positive relationship between county characteristics and county patent totals.
c Negative relationship between county characteristic and county patent totals.

Determinants of Innovation. Table 3 summarizes the influences of local and regional characteristics on nonmetro innovative activity. Each model uses total county patents from 1990 to 1999 as the measure of innovation, and the models are estimated for the 591 southern nonmetro counties in labor market areas with a metropolitan core. A different measure of metro innovative activity (patents, academic R&D, and industry R&D) is included in each model. Table 4 provides a list of local and regional characteristics selected and the data sources used.[8]

Table 4. County Characteristics and Data Sources

Characteristic	Description and Data Source
MANUFACTURING	Percent of total county employment in manufacturing, 1990 (County Business Patterns, CBP)
HIGH-TECH	Percent of total county employment in high-technology manufacturing, 1992 (Census of Manufacturers)
EMPLOYMENT	Total county employment, 1990 (CBP)
DISTANCE	Miles from largest city in county to the core city in LMA's metro area.
SCI-TECH	Percent of employment in scientific and technical occupations–computer science; engineering; natural, physical, and social sciences; 1990 (Bureau of Labor Statistics, BLS)
COLLEGE	Number of college students in county, 1990 (U.S. Census of Population)
DIVERSITY	Industry diversity, inverse of the two-digit SIC Hirschman-Herfindahl Index, 1990 (CBP)
SMALL EST	Number of small establishments (employment less than 20) per capita, 1990 (CBP)
LARGE EST	Number of large establishments (employment greater than 500) per capita, 1990 (CBP)
AMENITY	McGranahan index of natural amenities, 1999 (Economic Research Service, USDA)
REG PATENTS	Average of 1990–99 patent totals in contiguous counties (U.S. Trademark and Patent Office, USTPO)
MSA PATENTS	MSA patent totals, 1990–99 for core metro area in LMA (USTPO)
MSA UNIV R&D	MSA University expenditures for research and development, 1997–99 (National Science Foundation)
MSA SCI-TECH	MSA scientific and technical employment as percent of total employment, 1990 (BLS)

Nonmetro patent totals are positively associated with the size (employment) of the local economy. However, a relatively large manufacturing sector in the county is not related to patent activity. The absence of an association between innovation and a dominant manufacturing base may reflect conflicting forces. Patenting among manufacturers is high relative to other sectors, yet Glaeser and Saiz (2003) find that innovative firms avoid traditional manufacturing communities. Similarly, no significant relationship is evident between high-technology employment in nonmetro counties and patent totals.[9] Acs (2002) notes that the presence of high-technology industries facilitates the spillover of innovation in metropolitan areas. However, a base of high-tech firms in a nonmetro area appears to offer little advantage in terms of increased patenting activity. This is consistent with earlier findings by Barkley, Dahlgren, and Smith (1988) that nonmetro high-tech firms differ little from firms in traditional nonmetro manufacturing industries.

The structure of the local economy, as reflected in industrial diversity and establishment size, is hypothesized to influence innovative activity. An increase in local industrial diversity provides enhanced opportunities for inter-firm sharing of information.[10] Also, innovative activity is highest among small and large firms. Small firms have the flexibility to experiment with new products and processes (CHI 2002, 2004), and large firms have the resources to be actively involved in R&D (National Science Board, 2000). The findings for nonmetro counties are consistent with earlier research. Patenting activity was strongest in nonmetro counties characterized by a diverse industrial structure and a relatively large number of small establishments (employment fewer than twenty) or very large establishments (employment greater than 500).

The availability of local amenities and proximity to metro areas are positively associated with nonmetro patent totals. These findings may indicate that the more innovative firms are located in nonmetro counties with higher amenities and access to metro areas. Alternatively, the lead scientists on patents may reside in adjacent, high-amenity nonmetro counties but work in metro areas. Thus, these results may reflect residential rather than production location choices.

Nonmetro industry R&D (measured by the percentage of the labor force in science and technology occupations) and university R&D (measured by college enrollment) are proxy variables for inputs into the county innovation process. Both types of inputs were positively associated with patent totals for nonmetro areas. A local industry or university research base appears important to the development of new products and processes as reflected in patents. The college enrollment, however, is correlated with county size. Thus college enrollment may reflect agglomeration economies as well as university R&D expenditures.

Of principal interest to this study is the role of innovation spillovers in nonmetro county patent activity. A positive association is found between the patent totals in a county and patent activity in surrounding counties. That is, nonmetro counties with low patent totals tend to cluster, and counties with high patent totals tend to locate near similar counties. Recent research also finds evidence of technology spillovers within regions (Fischer and Varga, 2003; Lim, 2004; and Acs, 2002); however, this research also notes that these spillovers dissipate with distance. Evidence of the spread of innovative activity from metro areas to nearby nonmetro and rural counties is mixed. Patenting activity in nonmetro counties is positively associated with total patents in the labor market area's metro core. These findings are consistent with urban-to-rural knowledge spillovers. However, no significant relationships are found between nonmetro patent totals and (1) private R&D in nearby metro areas (as reflected in employment in scientific and technical occupations) or (2) expenditures for academic R&D in the metro counties. The absence of a strong link between nonmetro innovation and metro R&D is consistent with previous research. For example, in a study of innovation in Finland, McCann and Simonen (2005, 18) find "very little support for the argument that cooperation with universities, research institutes, or consultants plays any role in promoting innovation." Andersson, Quigley, and Wilhelmson (2004), however, find a positive relationship between university-based research in Sweden and the productivity of labor in the community, but they conclude that the external benefits are highly concentrated geographically. Finally, Zucker and Darby (2005) propose that star scientists are becoming more concentrated over time as they move to areas with many in their discipline. This concentration of "stars" may further limit the possibility of knowledge spillovers to nonmetro counties not near these centers of science and technology.

Conclusions

The findings of this research indicate that innovative activity exists in select areas of the nonmetro South, and this activity may serve as an engine for local economic development. The nonmetro areas with significant innovative activity are characterized by large employment bases, diverse industry structures, a relatively large share of employment in scientific and technical occupations, relatively large numbers of small or large establishments, high amenity ratings, and proximity to a metro area. Unfortunately, these centers of innovation in rural areas in the South are relatively rare. Only about twenty nonmetropolitan counties are identified as innovative "hot spots" or members of clusters of innovation. However, numerous nonmetropolitan counties have the foundations necessary for evolving into areas of significant innovation. Assets available to rural communities include local colleges and universities, state and federal government research centers, indigenous entrepreneurs and small businesses, and the natural amenities and quality of life to attract innovative and entrepreneurial resources from metropolitan areas. Nonmetropolitan areas that leverage these assets will remain competitive in the New Economy.

Alternatively, public R&D programs and policies that focus resources on current centers of innovation likely will lead to further concentration of economic activity in a relatively small number of metro areas and a few fortunate nonmetro counties near these metro centers of innovation. For most nonmetro counties in the South, centers of innovation in metro areas will be benign at best or detrimental if significant backwash effects exist. Therefore, programs and policies targeted at innovation and entrepreneurship in nonmetro areas will be needed if the nonmetro counties are to participate in the knowledge economy. Increased R&D expenditures at universities and government research centers in nonmetro counties may be helpful in stimulating innovation in these areas. In addition, the quality of the local labor force and the entrepreneurial environment must improve if increases in innovative activity are to result in new economic activity.

Endnotes

1. See Chesire and Malecki (2004) for a review of the literature on the role of innovation in economic development.
2. Throughout this discussion, "rural" and "nonmetropolitan" are used interchangeably to refer to nonmetropolitan counties. Similarly, "urban" and "metropolitan" are used to represent metropolitan statistical areas (MSA). The 1990 designation for metropolitan and nonmetropolitan is used in this study.
3. Gordan and McCann (2005) suggest that there are three common features of all innovations: newness, improvement, and the overcoming of uncertainty. It is unlikely that all patents equally provide the three features of innovation.
4. Labor Market Areas (LMAs) are multi-county regions that capture the inter-county commuting flows in the region. The procedures followed to delineate LMAs are documented in Tolbert and Killian (1987).
5. The Local Moran I is calculated using the following equation.

   Ii = Zi

   Where Ii = Local Moran for county i

   Zi = standardized value of patent counts (density) for county i

   Zj = standardized value of patent counts (density) for county j

   Wij = 1/n if i and j are contiguous, 0 otherwise

   The selected spatial weights matrix (W) is a contiguity matrix where wij = 0 if counties i and j are not contiguous and 1/n if the counties share a boundary (n = number of counties contiguous to county i). The county attributes are total patents for the period 1990–99.
6. The knowledge production function approach also is used by Jaffa, Trajtenberg, and Henderson (1993); Fritsch (2002); and Acs (2002).
7. Total R&D expenditures at universities and colleges are available from the National Science Foundation; however, only seven southern nonmetro colleges and universities were included on the NSF data base. Thus, we substituted the number of college students as a measure for potential university R&D. Scientific and technical professions (the PR measure) are defined as computer science; engineering, except civil; and natural, physical, and social sciences.
8. The dependent variable in the knowledge production functions, nonmetro county patents 1990–99, is count data with an overdispersion of observations of zero or near zero. All explanatory variables except metro patents and metro university R&D expenditures use 1990 values to control for possible endogeneity issues. The Zero Inflated Negative Binomial estimation procedure was used to account for overdispersion and zero values of the dependent variable (patent counts). See Lee (2006) for the complete estimation results.
9. The classifications for high-technology industries followed that of Markusen et al. (2001).
10. Industrial diversity is measured by the Krugman index. The Krugman (1991) index of county r is defined as:

$$D_r = \frac{1}{S_r} \text{ and } S_r = \sum_{i=1}^{n} \left| \frac{Emp_{i,r}}{Emp_r} - \frac{Emp_{i,us}}{Emp_{us}} \right|$$

   where Emp = employment, i = industry (one-digit SIC level), r = region (county in this study) , and U.S. = nation, n = number of one-digit SIC industries. A small value for Dr reflects a local industry that is concentrated in a few sectors relative to the nation.

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