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# EMPLOYMENT, INCOME, AND MIGRATION IN APPALACHIA: A SPATIAL SIMULTANEOUS EQUATIONS APPROACH*

**Gebremeskel H. Gebremariam**

*Department of Economics, 3033 Pamplin Hall, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061. E-mail: gebre@vt.edu*

**Tesfa G. Gebremedhin**

*Division of Resource Management, West Virginia University, P.O. Box 6108, Morgantown, WV 26506-6108. E-mail: tesfa.gebremedhin@mail.wvu.edu*

**Peter V. Schaeffer**

*Division of Resource Management, West Virginia University, P.O. Box 6108, Morgantown, WV 26506-6108. E-mail: peter.schaeffer@mail.wvu.edu*

**ABSTRACT.** Appalachia remains a symbol of poverty in the midst of prosperity. During the 1990s it fell further behind the rest of the nation. Persistent poverty during a period of strong growth is a serious as well as an interesting subject to study. We examine determinants of growth in Appalachia between 1990 and 2000. We show that employment, migration, and median household income were jointly determined by regional covariates and that county economic conditions were conditional on the performance in neighboring counties. One conclusion is that regional cooperation and geographically focused programs may yield the greatest returns to policy investments.

## 1. INTRODUCTION

Persistent poverty is one of the most critical social problems in the United States. Despite decades of intervention, billions of public dollars spent, and the strong economy of the 1990s, many communities remain poor (Rupasingha and Goetz, 2003). Even during the period of fast growth during the last decade of the 20th century, Appalachian counties suffered from high unemployment rates, a shrinking economic base, low human capital formation, and outmigration (Maggard, 1990; Deavers and Hoppe, 1992; Dilger and Witt, 1994; Hayness, 1997; Pollard, 2003; Black and Sanders, 2004). The slow growth of income and employment, outmigration, and the disappearance of rural households are both causes and effects of persistent high rates of poverty. Lagging economic development negatively affects the economic and social well-being of rural populations, the health of local businesses, and the ability of local governments to provide services (Cushing and Rogers, 1996).

Historically, the average socioeconomic status of Appalachians has been low and the region remained a symbol of poverty and underdevelopment in the midst of America's global power and prosperity (Pollard, 2003). Per capita market income was about

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TABLE 1: County Economic Indicators

| County Economic Level | Per Capita Market Income | Poverty Rate | Three-Year Average Unemployment Rate |
|---|---|---|---|
| Distressed | 67 % or less of U.S. average | 150% or more of U.S. average | 150% or more of U.S. average |
| Transitional | All counties not in one of the other classes. Individual indicators vary | | |
| Competitive | 80% or more of U.S. average | 100% or less of U. S. average | 100% or less of U.S. average |
| Attainment | 100% or more of U.S. average | 100% or less of U.S. average | 100% or less of U.S. average |

*Source:* Appalachian Regional Commission (2002).

77 percent of the U.S. average in 1960 and 31.1 percent of the region's residents lived in poverty, compared to 22.1 percent of all Americans (Wood and Bishak, 2000). The gap has narrowed since then and per capita income reached 84 percent of U.S. income in 1999. Similarly, the poverty rate had dropped to 13.6 percent by 1999, though it remained above the 12.4 percent for the U.S. (Pollard, 2003).

Educational attainment in Appalachia is also lower than in the rest of the country. In 2000, the proportion of Appalachian residents age 25 and older with a high school diploma and with at least bachelor's degree was 77 and 18 percent, respectively, compared to 81 and 25 percent for the U.S. The region also continues to be a destination for low-income populations with relatively little education, and low-occupational status, while those with higher incomes, more education and higher job status moved out during the second half of the 1990s (Obermiller and Howe, 2004). The availability as well as the quality of jobs, as measured by average wages, was about 10 percent lower in Appalachia than in the United States (Foster, 2003). In summary, Appalachia continues to be economically and socially distinct from the rest of the United States. It is less ethnically and racially diverse, has a higher median age, a higher share of elderly, and is more rural than the rest of the nation.

There is significant regional variation within Appalachia with respect to socio-economic status. The Appalachian Regional Commission (2002) classifies Appalachian counties into four categories: distressed, transitional, competitive, and attainment (Table 1). This system of classification is based on the comparison of three indicators of economic viability—per capita market income, poverty, and the three-year average unemployment rate—to their respective national average.

As indicated in Figure 1, most distressed counties are clustered in central Appalachia's coalfields and the southwestern portions of Appalachian Mississippi and Alabama. On the other side of the continuum are the attainment counties, of which there are few; they are found either in or near major metropolitan areas. Some 70 percent of counties are in the transitional stage.

One of the objectives of this study is to improve our understanding of the determinants and variations of regional growth. Therefore, this article examines the determinants of economic growth in Appalachia during the 1990s at the county level. This was a period of strong growth and we chose it because persistent poverty during a period of growth is a more serious as well as a more interesting subject to study.

The rest of this article is organized as follows. In section 2, we introduce the model, followed by a discussion of the data and their sources in section 3. In section 4, we present and analyze the empirical results. Finally, section 5 offers conclusions and policy implications.

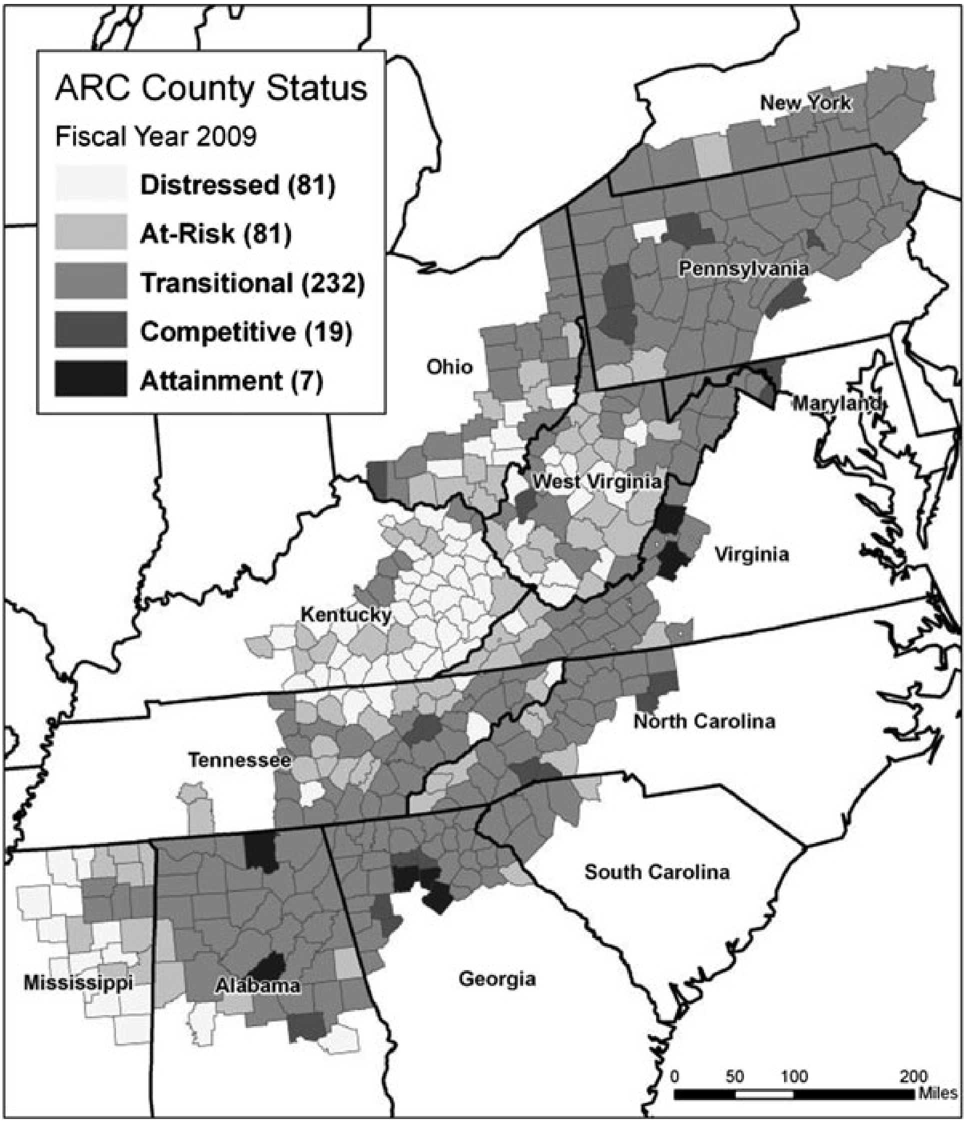


FIGURE 1: Counties by Status, 2009.

## 2. THE MODEL

The question whether "jobs follow people" or "people follow jobs" has led to research to identify the direction of causality, which resulted in the conclusion that regional development often reflects the interdependence between households' residential and firms' business location choices (Muth, 1971; Steinnes and Fisher, 1974). To account for this causation and interdependency, Carlino and Mills (1987) constructed a simultaneous equation system with two partial location equations. Boarnet (1994) provided a more general version of that model. The Carlino-Mills/Boarnet model has been adapted (e.g., Duffy-Deno and Eberts, 1991; Clark and Murphy, 1996; Henry et al., 1997; Barkley et al., 1998; Duffy-Deno, 1998; Deller et al., 2001; Edmiston, 2004) to examine different aspects of regional economic growth. We also employ the Carlino-Mills/Boarnet model structure.

Because of our interest in persistent poverty, we focus on employment, income, and migration. We assume that households locate to maximize utility and firms to maximize profits. That is, households migrate to capture higher wages or income and firms to be near growing consumer markets. These actions in turn generate income in the economy. Firms also respond to factors such as wage rates, tax rates, local public services, and regional location. Local governments may influence firms' location decisions by offering financial incentives. Regional factors that affect the decisions of households, firms, and local governments are likely to exhibit interdependence in the form of spatial autocorrelation, that is, the dependent variables or the error terms in different locations are correlated (Anselin, 1988, 2003) because the boundaries of political jurisdictions do not coincide with those of economic regions.

Based on these assumptions, we derive the following hypotheses:

1. Employment, migration behavior, and median household income growth are interdependent and jointly determined by county-level variables.
2. Employment, migration behavior, and median household income growth in any county are conditional upon initial conditions in that county.
3. Employment, migration behavior, and median household income growth in a county are conditional on employment, migration behavior, and median household income growth in neighboring counties.

To test these hypotheses, we develop a spatial simultaneous equations model of employment, migration, and household median income that builds on and extends the models established by Carlino and Mills (1987) and Boarnet (1994). The model incorporates own-county and neighboring counties effects. Based on theoretical and statistical considerations, a multiplicative functional form of the model was adopted. Duffy-Deno (1998) and MacKinnon et al. (1983) show that a log-linear specification is more appropriate for models involving population and employment densities than a linear specification.

The literature suggests that employment and median household income adjust to their equilibrium levels with a substantial lag (e.g., Mills and Price, 1984; Carlino and Mills, 1987; Boarnet, 1994; Duffy, 1994; Henry et al., 1997; Barkley et al., 1998; Duffy-Deno, 1998; Henry et al., 1999; Aronsson et al., 2001; Deller et al., 2001; Edmiston, 2004; Hamalainen and Bockerman, 2004). Therefore, we use a distributed lag or stock adjustment process to derive our empirical model, which is given below.

(1a)

$$\ln(INM_{it}) = \alpha_1 + \beta_{11}\ln(OTM_{it}) + \beta_{12}\ln(EMP_{it}) + \beta_{13}\ln(MHY_{it}) + \lambda_{11}\ln\left(\sum_{j=1}^{n} w_{ij}INM_{jt}\right) + \lambda_{12}\ln\left(\sum_{j=1}^{n} w_{ij}OTM_{jt}\right) + \lambda_{13}\ln\left(\sum_{j=1}^{n} w_{ij}EMP_{jt}\right) + \lambda_{14}\ln\left(\sum_{j=1}^{n} w_{ij}MHY_{jt}\right) + \sum_{k=1}^{K_1}\gamma_{1k}\ln\left(X_{kit}^{in}\right) + (1-\eta_{in})\ln(INM_{it-1}) + u_{it,1},$$

(1b)

$$\ln(OTM_{it}) = \alpha_2 + \beta_{21}\ln(INM_{it}) + \beta_{22}\ln(EMP_{it}) + \beta_{23}\ln(MHY_{it}) + \lambda_{21}\ln\left(\sum_{j=1}^{n} w_{ij}OTM_{jt}\right) + \lambda_{22}\ln\left(\sum_{j=1}^{n} w_{ij}INM_{jt}\right) + \lambda_{23}\ln\left(\sum_{j=1}^{n} w_{ij}EMP_{jt}\right) + \lambda_{24}\ln\left(\sum_{j=1}^{n} w_{ij}MHY_{jt}\right) + \sum_{k=1}^{K_2}\gamma_{2k}\ln\left(X_{kit}^{ot}\right) + (1-\eta_{ot})\ln(OTM_{it-1}) + u_{it,2},$$

(1c)

$$\ln(EMP_{it}) = \alpha_3 + \beta_{31}\ln(INM_{it}) + \beta_{32}\ln(OTM_{it}) + \beta_{33}\ln(MHY_{it}) + \lambda_{31}\ln\left(\sum_{j=1}^{n} w_{ij}EMP_{jt}\right) + \lambda_{32}\ln\left(\sum_{j=1}^{n} w_{ij}INM_{jt}\right) + \lambda_{33}\ln\left(\sum_{j=1}^{n} w_{ij}OTM_{jt}\right) + \lambda_{34}\ln\left(\sum_{j=1}^{n} w_{ij}MHY_{jt}\right) + \sum_{k=1}^{K_3}\gamma_{3k}\ln\left(X_{kit}^{em}\right) + (1-\eta_{em})\ln(EMP_{it-1}) + u_{it,3},$$

(1d)

$$\ln(MHY_{it}) = \alpha_4 + \beta_{41}\ln(INM_{it}) + \beta_{42}\ln(OTM_{it}) + \beta_{43}\ln(EMP_{it}) + \lambda_{41}\ln\left(\sum_{j=1}^{n} w_{ij}MHY_{jt}\right) + \lambda_{42}\ln\left(\sum_{j=1}^{n} w_{ij}INM_{jt}\right) + \lambda_{43}\ln\left(\sum_{j=1}^{n} w_{ij}OTM_{jt}\right) + \lambda_{44}\ln\left(\sum_{j=1}^{n} w_{ij}EMP_{jt}\right) + \sum_{k=1}^{K_4}\gamma_{4k}\ln\left(X_{kit}^{mh}\right) + (1-\eta_{mh})\ln(MHY_{it-1}) + u_{it,4},$$

$\alpha_r, \beta_{rq}, \lambda_{rl}, \gamma_{rk}$ for $k = 1, \ldots, K_r$; $r, l = 1, \ldots, 4$; and $q = 1, \ldots, 3$ are the parameter estimates of the model, and $K_r$ is the number of exogenous variables in the respective equations. $INM_{it}$, $OTM_{it}$, $EMP_{it}$, and $MHY_{it}$ are the levels of gross inmigration, gross outmigration, private business employment, and median household income in county $i$ at time $t$, respectively. The additional exogenous variables that are included in the respective equations of the system in (1a)–(1d) are given by $X_{kit}^{in}$, $X_{kit}^{ot}$, $X_{kit}^{em}$, and $X_{kit}^{mh}$, for $k = 1, \ldots, K_r$, $r = 1, \ldots, 4$.

$w_{ij}$ is a measure of proximity between locations $i$ and $j$. We set $w_{ij}$ equal to $1/c_i$, where $c_i$ is the number of nonzero elements in row $i$. If $i$ and $j$ are adjacent, then $w_{ij} > 0$, and zero otherwise (queen's rule). The resulting matrix, $\boldsymbol{W}$, is a row standardized spatial weights matrix with zero diagonal values. Thus, each endogenous variable in equations (1a)–(1d) is expressed as a function of the exogenous variables, the realizations of the other dependent variables, and of the spatial lags of the dependent variables because in a spatially connected world, what happens in county $i$ can change the values in county $j$ ($i \neq j$). In spite of their often rural nature, Appalachian counties are strongly interconnected, as indicated, for example, by mean commuting times, which in 2000 were almost the same (24.8 minutes) as the U.S. average (25.5 minutes), and which in the 1990s grew faster (18.8 percent) than the national average (14.1 percent). Residents of distressed counties had the longest mean commutes (28 minutes) and experienced the greatest increase (22.4 percent), which suggests responsiveness to changing economic conditions in the home as well as in other counties (Mather, 2004).

The subscript $t-1$ refers to the variables lagged by one period, which in this study is one decade. $\eta_{in}$, $\eta_{ot}$, $\eta_{em}$, and $\eta_{mh}$ are speed of adjustment parameters. They indicate the rates at which inmigration, outmigration, employment, and median household income adjust to their respective equilibrium levels.

The nature of the disturbance includes spatial and nonspatial elements. The spatial parts of the error terms reflect the spatial correlation. Anselin and Kelejian (1997) provided a Moran's I test statistic for models with endogenous regressors, and Kelejian and Prucha (2001) developed a more general version of the test. Performance of the test confirmed the existence of spatial autocorrelation in the errors in all equations. The test results are reported with the estimation results below. Therefore, the disturbance term in the $r$th equation is generated as

$$u_{it,r} = \rho_r \sum_{j=1}^{n} w_{ij} u_{jt,r} + \varepsilon_{it,r}, \quad r = 1, \ldots, 4,$$

where $\rho_r$ is the coefficient of spatial correlation. This specification relates the disturbance term in the $r$th equation to its own spatial lag. The innovations ($\varepsilon_{it,r}$, $r = 1, \ldots, 4$) are distributed iid $(0, \sigma_r^2)$, $r = 1, \ldots 4$. Hence, they are not spatially correlated. However, analogous to the classical simultaneous equation model, the specification allows for innovations that correspond to the same cross sectional unit to be correlated across equations. As a result, the disturbance terms are spatially correlated across units and across equations.

## 3. DATA

Table 2 provides a summary of the data sources and variable names. Data for the 418 Appalachian counties come from County Business Patterns, Bureau of Economic Analysis, Bureau of Labor Statistics, Current Population Survey Reports, County and City Data Book, U.S. Census of Population and Housing, U.S. Small Business Administration, and the Department of Employment Security. County-level data for employment, gross inmigration, gross outmigration, and median household income are for 1990 and 2000. Data for a number of additional control variables have been collected for 1990 from different sources.

### *Endogenous Variables*

The endogenous variables include year 2000 levels of private nonfarm employment ($EMP_t$), gross inmigration ($INM_t$), gross outmigration ($OTM_t$) and median household income ($MHY_t$). We use gross migration because the use of net migration involves a substantial loss of information and provides no apparent advantages (Greenwood, 1975). The effects of migration on sending and receiving counties depend on the characteristics of the migrants themselves and inmigrants and outmigrants are unlikely to have nearly identical characteristics. Median household income is used as an overall measure of county-level income. Spatially lagged levels of private employment ($WEMP_t$), gross inmigration ($WINM_t$), gross outmigration ($WOTM_t$), and median household income ($WMHY_t$) are the additional endogenous variables included in the model.

### *Initial Condition Variables*

The 1990 values for nonfarm employment ($EMP_{t-1}$), gross inmigration ($INM_{t-1}$), gross outmigration ($OTM_{t-1}$), and median household income ($MHY_{t-1}$) are the initial conditions.

TABLE 2: Variable Descriptions and Data Sources

| Variable | Description | Data Source |
|---|---|---|
| *Endogenous Variables* | | |
| $EMP_t$ | Level of employment, 2000 | County & City Data Book |
| $INM_t$ | Level of gross inmigration, 2000 | Internal Revenue Service |
| $OTM_t$ | Level of gross outmigration, 2000 | Internal Revenue Service |
| $MHY_t$ | Level of median household income, 1999 | BEA |
| *Spatially Lagged Endogenous Variables* | | |
| $WEMP_t$ | Spatial lag of EMP 2000 | Computed |
| $WINM_t$ | Spatial lag of INM 2000 | Computed |
| $WOTM_t$ | Spatial lag of OTM 2000 | Computed |
| $WMHY_t$ | Spatial lag of MHY 1999 | Computed |
| *Initial Condition Variables* | | |
| $EMP_{t-1}$ | Employment, 1990 | County & City Data Book |
| $INM_{t-1}$ | Inmigration, 1990 | Internal Revenue Service |
| $OTM_{t-1}$ | Outmigration, 1990 | Internal Revenue Service |
| $MHY_{t-1}$ | Median household income, 1989 | BEA |
| *Regional and Policy Variables* | | |
| *AREA* | Land area in square miles, 1980 | U.S. Bureau of the Census |
| *POPs* | Population, 1990 | U.S. Bureau of the Census |
| *POP25-44* | Percentage of population between 25–44 years old , 1990 | U.S. Bureau of the Census |
| *FHHF* | Percentage of female householder, family householder, 1990 | County & City Data Book |
| *SCRM* | Serious crime per 100,000 pop., 1990 | County & City Data Book |
| *POPCD* | Persons 25 years and older, % bachelor's degree or higher, 1990 | County & City Data Book |
| *OWHU* | Owner-occupied housing unit in percent, 1990 | U.S. Bureau of the Census |
| *MVH* | Median value of owner-occupied housing | U.S. Bureau of the Census |
| *MCRH* | Median contract rent of specified renter-occupied,1990 | U.S. Bureau of the Census |
| *UNEMP* | Unemployment rate,1990 | Bureau of Labor Statistics |
| *MANU* | % employed in manufacturing,1990 | County & City Data Book |
| *WHRT* | % employed in wholesale and retail trade , 1990 | County & City Data Book |
| *PCPTAX* | Property tax per capita, 1990 | County & City Data Book |
| *SCIX* | Social Capital Index , 1990 | Rupasingha et al., 2006 |
| *NAIX* | Natural Amenities Index, 1990 | USDA |
| *HWD* | Highway density , 1990 | US Highway Authority |
| *ESBd* | Establishment density , 1990 | County Business Pattern |
| *EXPTAX* | Personal income tax per capita /local government expenditure per capita ("tax price"), 1990 | Computed |

### *Independent Variables*

Independent variables include demographic, human capital, labor market, housing, industry structure, amenity, and policy variables. Unless otherwise indicated, initial values of the independent variables are used in the analysis. This reduces the problem of endogeneity.[1] All independent variables are in log form, except those that

[1]As one of the referees pointed out, many of our independent variables cannot be considered truly independent. For example, several of the variables will be affected by (in or out) migration. However, in our model, we take these "independent" variables as predetermined and using lagged (1990) values reduces the problem.

can take negative or zero values. Descriptions of the independent variables follow below.

Equations (1a) and (1b) contain the variables ($X^{in}_{kit}$), $k = 1, \ldots, K_1$, and ($X^{ot}_{kit}$), $k = 1, \ldots, K_2$, which include variables believed to affect county gross inmigration in and gross outmigration. These include the county unemployment rate (*UNEMP*), county area (*AREA*), county initial population size (*POPs*), percentage of owner occupied dwellings (*OWHU*), median contract rent or housing cost (*MCRH*), McGranahan's (1993) Natural Amenity Index (*NAIX*), and personal income tax per capita per unit of local government expenditure per capita (*EXTAX*).

The county unemployment rate (*UNEMP*) indicates the extent of economic distress and is expected to have a negative influence on net migration. *POPs* is included to account for the positive impacts of the potential spillover effects and economic opportunities associated with larger population areas on net migration. *OWHU* is a measure of community stability and neighborhood quality, which are indicators of attraction to migrants. *MCRH* accounts for the potential impacts of the cost of renter-occupied housing on inmigration. To account for the differential impact of the quality of places on migration behavior, *NAIX* is included in both equations. *EXTAX* is included in both equations to measure how much of the tax paid is returned in the form of local public services, which may influence the differential effects of migration behavior more than the absolute amount of tax paid (White and Knapp, 1994).

Equation (1c) includes the variables ($X^{em}_{kit}$), $k = 1, \ldots, K_3$, which consist of human capital, agglomeration effects, unemployment, and other regional socioeconomic variables that are assumed to influence county employment. Human capital is measured as the percentage of adults 25 years and older with college degrees or higher (*POPCD*). We expect a positive association between educational attainment and employment. To control for agglomeration effects from both the supply and the demand side, the percentage of the population between 25 and 44 years of age (*POP25–44*) is included. We expect that agglomeration effects have a positive impact on employment. The proportion of families headed by a female householder (*FHHF*) is included to control for the effect of local labor market characteristics on employment. The county unemployment rate (*UNEMP*) is used as a measure of local economic distress. A high unemployment rate is normally associated with a poor economic environment and may provide an incentive for individuals to form new businesses that may employ not only the owners, but also others. We cannot say *a priori* whether the impact of *UNEMP* on employment is positive or negative. Business establishment density (*ESBd*), which is the total number of private sector establishments in the county divided by the total county's population, is included to capture the degree of competition among firms and crowding of businesses relative to the population. We expect the coefficient to be negative.

$X^{em}_{kit}$, $k = 1, \ldots, K_3$, includes the median value of owner-occupied housing (*MVH*), which is used as a proxy for availability of financial resources to fund businesses. *MVH* is therefore expected to be positively associated with employment growth in the county. Also included in $X^{em}_{kit}$ are property taxes per capita (*PCPTAX*), percentage of private employment in manufacturing (*MANU*), the percentage of employment in the wholesale and retail trade (*WHRT*), *NAIX*, and highway density (*HWD*).

Equation (1d) contains the variables ($X^{mh}_{kit}$), $k = 1, \ldots, K_4$, which include *POPs*, *FHHF*, *POPCD*, *MVH*, *UNEMP*, and the social capital index (*SCIX*). *SCIX* is a county-level index that incorporates density of associations such as civic groups, religious organizations, sport clubs, labor unions, political and business organizations, percentage of voters who vote for presidential elections, county-level response rate to the Census Bureau's decennial census, and the number of tax-exempt nonprofit organizations (Rupasingha et al., 2006). The initial levels of employment ($EMP_{t-1}$), gross inmigration ($INM_{t-1}$), gross outmigration ($OTM_{t-1}$), and median household income ($MHY_{t-1}$) are treated as predetermined because their values are given at the beginning of each period and hence are not affected by the endogenous variables.

## 4. RESULTS AND DISCUSSION

We used the Feasible Generalized Three-Stage Least Squares (FGS3SLS) estimator, as outlined by Kelejian and Prucha (2004), to estimate the parameters of the system given in (1a)–(1d) using an instrument matrix **Q** that consists of a subset of linearly independent columns of $[X, WX, W^2X]$, where **X** is the matrix that includes the control variables in the model and **W** is the row standardized spatial weights matrix mentioned above.

Table 3 reports the FGS3SLS parameter estimates of Equations (1a)–(1d). Most estimates are consistent with theoretical expectations. The contemporaneous effects with respect to employment, inmigration, outmigration, and median household income are highly significant, indicating the existence of strong simultaneity feedback among the dependent variables. The results also reveal strong spatial autoregressive lags and spatial cross-regressive lag simultaneities. However, in three of the four equations the results do not support the hypothesis of conditional convergence, as indicated by statistically insignificant coefficients of the respective lagged dependent variables.

### *Employment–EMP Equation*

The results indicate that the county employment level is dependent on contemporaneous gross inmigration, gross outmigration, and median household income. Each of these variables, in turn, is affected by the level of contemporaneous employment. The coefficient for *INM*, for example, is positive and significant at the 1 percent level. The coefficient for *EMP* in the *INM* equation is also positive and significant at the 1 percent level. These results indicate that counties with high levels of inmigration are favorable to employment and that employment stimulates additional inmigration. Note that the positive effect of employment is greater than the effect of gross inmigration on employment, as indicated by the level of the coefficients on the respective variables. This is consistent with the Todaro hypothesis of rural-urban migration that one job opening generates more than one inmigrant. Similarly, the interdependence between the level of employment and gross outmigration is strong but negative. The coefficient for *OTM* is negative and statistically significant at the 1 percent level. The coefficient for *EMP* in the *OTM* equation is also negative and statistically significant at the 1 percent level. This means that counties with outmigration have characteristics that discourage employment. The lack of employment, in turn, encourages outmigration. Note again that the contemporaneous effects of *EMP* on *OTM* are stronger than those of *OTM* on *EMP,* as indicated by their respective coefficients.

The results also show strong positive feedback simultaneity between *EMP* and *MHY*, as indicated by the positive and statistically significant coefficient for *MHY* in the *EMP* equation, and the statistically significant coefficient for *EMP* in the *MHY* equation, respectively. This interdependence is consistent with economic theory and empirical results (e.g., Armington and Acs, 2002). Increases in the demand for goods and services that result from increases in family income are associated with increases in employment, which create opportunities for even more people to work and earn income. Note, however, that the positive effect of median household income on employment is weaker than that of employment on median household income. This is possible because the increase in the demand for labor is also associated with increases in demand for other factors of production, such as capital and land. Thus, beside labor, owners of capital and land will earn

TABLE 3: Feasible Generalized Spatial Three-Stage Least Squares (FGS3SLS) Estimation Results

| | EMP Equation | | INM Equation | | OTM Equation | | MHY Equation | |
|---|---|---|---|---|---|---|---|---|
| *Variable* | *Coefficient* | *t-statistic* | *Coefficient* | *t-statistic* | *Coefficient* | *t-statistic* | *Coefficient* | *t-statistic* |
| *CONSTANT* | −1.279* | −1.871 | −6.037*** | −6.515 | 4.856*** | 6.800 | −3.666*** | −2.616 |
| $EMP_t$ *Employment 2000* | | | 0.737*** | 11.776 | −0.682*** | −19.128 | 0.785*** | 9.286 |
| $INM_t$ *Inmigration 2000* | 0.167*** | 5.113 | | | 0.337*** | 14.558 | −0.251*** | −4.485 |
| $OTM_t$ *Outmigration 2000* | −0.415*** | −8.048 | 0.938*** | 9.977 | | | 0.579*** | 4.676 |
| $MHY_t$ *Median household income 1999* | 0.101** | 2.306 | −0.318*** | −6.586 | 0.144*** | 4.295 | | |
| $WEMP_t$ *Spatial lag of EMP 2000* | 0.760*** | 26.155 | −0.182*** | −2.648 | 0.454*** | 12.044 | −0.660*** | −7.400 |
| $WINM_t$ *Spatial lag of INM 2000* | −0.066*** | −4.356 | 0.025 | 1.018 | −0.024 | −1.378 | 0.011 | 0.346 |
| $WOTM_t$ *Spatial lag of OTM 2000* | 0.476*** | 8.541 | −0.260*** | −2.815 | 0.342*** | 5.471 | −0.393*** | −3.187 |
| $WMHY_t$ *Spatial lag of MHY 1999* | −0.248*** | −5.617 | 0.134* | 1.868 | −0.066 | −1.316 | 0.872*** | 12.496 |
| *AREA County area in square miles* | | | 0.018 | 1.289 | −0.033*** | −3.379 | | |
| *POPs Population 1990* | | | 0.302*** | 8.556 | −0.242*** | −10.492 | 0.200*** | 4.129 |
| *POP25_44 Percentage of population 25–44 years old 1990* | 0.241*** | 3.526 | | | | | | |
| *FHHF Percentage of female family householder 1990* | | | | | | | 0.306*** | 4.567 |
| *POPCD Persons 25 and over, % with college degree or higher* | −0.006 | −0.328 | | | | | 0.098 | 0.557 |
| *OWHU Owner-occupied housing units in percent 1990* | | | | | 0.380*** | 4.287 | | |
| *MVH Median value of OWHU* | 0.108*** | 2.926 | | | | | 0.091 | 1.306 |
| *MCRH Median contract of rent specified rent-occupied 1990* | | | −0.005 | −0.071 | | | | |
| *UNEMP Unemployment rate 1990* | | | −0.050* | −1.869 | −0.009 | −0.496 | −0.014 | −0.496 |
| *MANU Percent employed in manufacturing 1990* | 0.080*** | 10.971 | | | | | | |
| *WHRT Percent employed in wholesale and retail trade 1990* | 0.253*** | 12.590 | | | | | | |
| *PCPTAX Property tax per capita 1990* | 0.003 | 0.204 | | | | | | |
| *SCIX Social capital index 1990* | | | | | | | 0.049** | 2.009 |
| *NAIX Natural amenities index 1990* | −0.003 | −0.735 | 0.001 | 0.194 | −0.006 | −1.415 | | |
| *HWD Highway density 1990* | −0.018 | −1.291 | | | | | | |
| *ESBd Establishment density 1990* | −0.054*** | −3.335 | | | | | | |

Continued

TABLE 3: Continued

| | EMP Equation | | INM Equation | | OTM Equation | | MHY Equation | |
|---|---|---|---|---|---|---|---|---|
| *Variable* | *Coefficient* | *t-statistic* | *Coefficient* | *t-statistic* | *Coefficient* | *t-statistic* | *Coefficient* | *t-statistic* |
| *EXTAX Personal income tax per capita/Local Expenditure per capita 1990* | | | −0.132*** | −4.999 | 0.178*** | 12.786 | | |
| $EMP_{t-1}$ *Employment 1990* | 0.007 | 0.224 | | | | | | |
| $INM_{t-1}$ *Inmigration 1990* | | | 0.638*** | 16.951 | | | | |
| $OTM_{t-1}$ *Outmigration 1990* | | | | | 0.012 | 0.314 | | |
| $MHY_{t-1}$ *Median household income 1989* | | | | | | | 0.023 | 0.568 |
| *RHO* (ρ) *Spatial autoregressive parameters* | 0.081 | | 0.034 | | 0.125 | | −0.499 | |
| *SIGM* (σ) *Variance-covariance parameters* | 0.008 | | 0.022 | | 0.01 | | 0.054 | |
| Moran I | 0.084 | 2.909[a] | 0.053 | 1.671[a] | 0.118 | 3.198[a] | −0.468 | −4.653[a] |
| n Observations | 418 | | 418 | | 418 | | 418 | |
| ETA (η) Speed of adjustment parameters | 0.993 | | 0.362 | | 0.988 | | 0.977 | |

*Note*: *, **, and *** denote statistical significance levels of 10 percent, 5 percent, and 1 percent, respectively.
[a]Z-values for Moran I.

additional income, further increasing average regional income. This is so even if the scale of production is capital or labor, or capital and labor intensive.

The results show a positive and significant parameter estimate for the spatial autoregressive lag variable (*WEMP*). This coefficient represents the spatial autoregressive simultaneity and indicates that the level of employment in one county tends to spillover to its neighboring counties. The estimation also resulted in a positive and significant parameter estimate for the spatial cross-regressive variable with respect to gross outmigration (*WOTM*) indicating that an increase in gross outmigration in neighboring counties tends to encourage employment in a given county. This is possible because outmigrants from neighboring counties may end up in the county and provide the capital and labor required for business expansion. Our results also show negative and significant spatial cross-regressive effects with respect to gross inmigration and median household income. This is consistent with economic theory because an increase in income in neighboring counties encourages firms and people to migrate to the neighboring counties in search of markets and jobs. Those firms and individuals take income, capital, and skills with them, leading to a decline in employment and likely to a decline in prospects for future growth, as well, though the latter does not follow from the results. These are potentially important results from a policy perspective as they indicate that the level of employment in one county has positive spillover effects on employment in neighboring counties, but that an increase in income will delay or harm it. More generally, the significant spatial autoregressive and spatial cross-regressive lag effects indicate that *EMP* depends not only on characteristics within the county, but also on those of its neighbors. Hence, in empirical work involving employment, gross inmigration, outmigration, and household income, testing for spatial effects is advisable. From a policy perspective, the results suggest that regional approaches might have a greater chance of success than local or county-wide economic development policies.

The model incorporates an autoregressive spatial process (effect), in addition to the spatial lag in the dependent variables. The results in Table 3 show a positive parameter estimate for $\rho_3$, indicating that random shocks into the system with respect to employment do not only affect the county where the shocks originated and its neighbors, but create positive shock waves across Appalachia.

To control for agglomeration effects, the model includes a demographic measure such as the percentage of the population between 25 and 44 years old (*POP25_44*). Members of this group tend to be better educated, attracted to urban areas, and provide a source of entrepreneurial talent. The empirical results show that *POP25_44* has positive and significant effects on $EMP_t$. This is consistent with previous studies (e.g., Acs and Armington, 2004), which indicate that a growing population increases the demand for consumer goods and services, as well as the pool of potential entrepreneurs who may create businesses. This result indicates that counties with high population concentrations benefit from resulting agglomerative and spillover effects that lead to localization of economic activities, in line with Krugman's (1991a, 1991b) argument on regional spillover effects. Contrary to expectations, however, the initial human capital endowment, measured by the percentage of adults (over 25 years old) with a college degree (*POPCD*), showed a negative result. One possible interpretation of this result is that many of the jobs created in Appalachia during the study period did not require high education levels.

The coefficient for business establishment density (*ESBd*) is negative and significant, indicating that the Appalachian region has reached the threshold where competition among firms for consumer demand is crowding businesses. According to the results, *ESBd* is associated with low levels of employment, suggesting that firms have exhausted localization and agglomeration economies of scale.

The coefficient for the median value of housing (*MVH*) is positive and significant at the 1 percent level. This means that a higher value of owner occupied housing is positively associated with business formation. This result is consistent with the expectation that a high housing value is an indicator of the capacity to finance a new business by potential entrepreneurs, either by using the house as collateral on a loan application or as a more general the availability of personal financial resources to start new business (Keeble and Walker, 1994; Reynolds, 1994).

The coefficients for variables *MANU* and *WHRT* are both positive and significant at the 1 percent level. These results indicate that counties with high initial percentages of their labor force employed in manufacturing and in wholesale and retail trades, respectively, showed a higher growth rate in business formation than other counties.

### *Inmigration—INM Equation*

The level of gross inmigration to a county depends on contemporaneous levels of employment, gross outmigration, and median household income as indicated by the highly statistically significant coefficients of the endogenous variables of the *INM* equation interdependences. The feedback simultaneity between gross outmigration and gross inmigration is positive and strong, indicating that counties that are characterized by high gross outmigration were also migration destinations during the study period. This is possible because outmigrants and inmigrants could be people with different labor market characteristics. Besides, a growing share of inmigrants in a county reflects a growing share of migration-prone residents, which is likely to also increase outmigration from the county. The migration literature indicates that migrants in one period are more likely than nonmovers to move in subsequent periods.

The interdependence between gross inmigration and median household income is negative and strong. This indicates that high-income counties are associated with low inmigration. This could be due to the fact that some migrants prefer low-income locations. Clark and Hunter (1992), for example, found that movers in their early 20s as well as migrants 35 years and older prefer low-income locations. Knapp and Graves (1989) suggest that higher incomes may be associated with, or compensate for, lower amenity levels, so that higher incomes cannot automatically be expected to attract inmigration.

Turning to the spatial autoregressive lag and spatial cross-regressive lag effects, the coefficient for the spatial autoregressive lag variable is positive but not significant, indicating the absence of spatial autocorrelation with respect to inmigration. The coefficients of the spatial cross-regressive lag variables with respect to employment (*WEMP*) and outmigration (*WOTM*), however, are negative and statistically significant at the 1 percent level. This indicates that inmigration in one county is negatively associated with employment and outmigration in neighboring counties. Neighboring counties' household incomes, on the other hand, have positive effects on the level of inmigration in a given county, as indicated by the positive and statistically significant parameter estimate for *WMHY*.

We obtained a positive parameter estimate for $\rho_1$. This indicates that random shocks to the system with respect to gross inmigration affect the county where the shocks originated, its neighbors, and create positive shock waves across Appalachia.

The results show a positive and significant association between the initial period population size (*POPs*) and inmigration to a given county. This suggests that people migrate to counties with high population concentrations. The coefficient for *POPs* in the outmigration equation is negative and statistically significant at the 1 percent level, indicating that factors in counties with high population concentrations discourage outmigration and vice versa. The two results suggest that Appalachian counties characterized by small and dispersed communities have been losing people during the study period. Since Appalachia is dominated by such counties, this is an important policy finding.

The outmigration of people, mostly the young and better educated, usually results in the erosion of community income and the property tax bases that provide the major sources of revenue to finance local public services. As a result, governments must either increase the per capita cost or decrease the quantity and/or quality of public services. As the results of this study show, this encourages further outmigration. The results also show that an increase in the tax price per capita discourages inmigration to a given county. This is indicated by the significant positive and negative coefficients for the *EXTAX* variable, which is derived by dividing the per capita personal income tax by local government expenditure per capita, in the inmigration and outmigration equations, respectively.

A declining population not only increases the per capita cost of providing local public services, but also constrains the expansion and growth of employment by limiting the supply of labor and the demand for business products. A declining quality and quantity of public services also reduces the earning capacity of residents and discourages business and employment growth. The ultimate result is the perpetuation of poverty and underdevelopment. The significant spatial interdependence suggests that neighboring counties may need to pool their resources in their efforts to promote growth, as mentioned above when we discussed the *EMP* equation.

*Outmigration—OTM Equation*

The results from the outmigration equation show similar trends with strong feedback simultaneities present. Gross outmigration is negatively associated with contemporaneous level of employment and positively associated with contemporaneous inmigration and median household income, as indicated by statistically significant coefficients (all at the 1 percent level) of *EMP*, *INM*, and *MHY*. The results also show a strong positive spatial autoregressive lag effect, indicated by the statistically significant coefficient for *WOTM*, and a positive spatial cross-regressive lag effect with respect to employment, indicated by the statistically significant coefficient of *WEMP*. This result suggests that outmigration in one county is associated with high levels of outmigration and employment in neighboring counties. The positive spatial autoregressive lag effect shows that spatial clustering with respect to outmigration exists in Appalachia. Counties with declining populations are losing their population as are their neighbors. The policy implication of this finding is that counties with declining population may need to pool their resources to deal with their problems.

We obtained a positive estimate for $\rho_2$, indicating that random shocks into the system with respect to gross outmigration affect not only the county where the shocks originated, but also its neighbors, and create positive shock waves across Appalachia.

The results show a positive and statistically significant coefficient estimate for *OWHU.* This contradicts theoretical expectations. Owning a house is expected to decrease the propensity to migrate due to transaction costs and the relative illiquidity of real estate in locations of economic distress. Investing in housing of your own may also reflect a decision to stay in the area of current residence for long. Empirical research supports this view. For example, Oswald (1996) presents evidence that in a number of countries increases in home ownership increased unemployment by reducing workers' mobility. A 10 percent rise in owner-occupation was associated with approximately a 2 percent increase in the unemployment rate.

Contrary to these theoretical expectations and empirical findings, however, the estimated coefficient of *OWHU* is positive and statistically significant at the 1 percent level, meaning that home ownership is positively associated with outmigration during the study period. This result reflects that home ownership in Appalachia was positively associated with the level of economic distress during the study period. Home ownership was higher in distressed counties (76 percent) and lower in attainment counties (72 percent); higher in central Appalachia than in northern or southern sub regions (more developed). Appalachian nonmetro areas also had higher ownership rates (76 percent) than metro areas (72 percent) (Pollard, 2003). Thus, this result further reflects that the direction of outmigration during the study period was from small dispersed and distressed communities. Obermiller and Howe (2004) also show that the overall direction of internal migration in Appalachia remained rural-to-urban during the 1990s.

Finally, the elasticity of $OTM_t$ with respect to the initial gross outmigration level ($OTM_{t-1}$) is negative and statistically significant. This indicates convergence in the sense that counties with a low level of gross outmigration at the beginning of the period tend to have higher rate of growth of gross outmigration toward their respective steady-state values than counties with high initial levels of gross outmigration, conditional on the other explanatory variables in the model. The speed of adjustment $\eta_{ot}$ is calculated as 0.362, that is, about 36.2 percent of the equilibrium rate of growth in gross outmigration was realized during the study period, 1990–2000, giving a half-life time of 19.06 years. Note, however, that dynamic stability issues are difficult to assess because of the complexity of calculating the required reduced form from Equations (1a)–(1d).

### *Median Household Income–MHY Equation*

Similar to estimates for the other equations, the estimates from the *MHY* equation show the existence of significant feedback simultaneity, spatial autoregressive lag simultaneity and cross-regressive lag simultaneities. The contemporaneous effect with respect to the level of employment on median household income is positive and statistically significant at the 1 percent level. This indicates that high levels of median household income are positively associated with high levels of employment, which is consistent with the theoretical expectations.

The contemporaneous effect with respect to the level of outmigration on the level of median household income is also positive and statistically significant at the 1 percent level. This result suggests that median household income increases with outmigration. This, in turn, means that the average income of the outmigrants is lower than the median income of the nonmovers. The contemporaneous effect with respect to inmigration on the level of median household income is negative and statistically significant at the 1 percent level. This result also indicates that median household income in a given county is negatively associated with the level of inmigration to that county. This, in turn, suggests that the average income of the inmigrants is lower than the median income of the nonmovers. These two results show that on average movers were poorer than stayers. This result is consistent with the findings of Obermiller and Howe (2004).

The spatial autoregressive lag effect is positive and statistically significant at the 1 percent level, indicating that the median household income level in a given county is positively affected by the median household income level in neighboring counties. This strong spatial spillover effect is an indication that there is clustering of counties in Appalachia on the basis of their median household incomes. An exploratory spatial data analysis on the same data set indicates that most of the low-income counties are clustered in Central Appalachia, whereas high-income counties are mostly clustered around larger cities in the northern and southern Appalachian sub regions.

There is also a significant negative spatial cross-regressive lag effect with respect to the level of employment. This means that the median household income in a given county is negatively associated with the employment level in neighboring counties. Maybe when employment increases in neighboring counties, the county will lose economic activities to them and ultimately end up losing income. The spatial cross-regressive lag effect with respect to the level of outmigration is also negative and statistically significant at the 1 percent level. Since the direction of migration, as indicated above, is away from distressed counties, this result could indicate that neighbors of distressed counties are also distressed, a further indication of the clustering of poverty in Appalachia.

The parameter estimate for $\rho_4$ is negative. Thus, random shocks into the system with respect to median household income affect the county where the shocks originated and its neighbors, and create negative shock waves across Appalachia.

Turning to the conditioning variables in the *MHY* equation, the empirical results indicate that median household income is positively and significantly associated with the initial population size (*POPs*), the percentage of families with a female householder (*FHHF*), and the social capital index (*SCIX*). *POPs* is positively associated with *MHY* due to the beneficial effects of agglomeration economies of firm location. A growing population captures the extent to which counties are relatively attractive to migrants. A growing population also increases the demand for consumer services and thus encourages business and employment growth, which leads to income growth. The coefficient for the index of social capital (*SCIX*) is also positive and significant, suggesting that counties with high levels of social capital increase the wellbeing of their communities. This result is consistent with expectations. On the other hand, the positive effects of the *FHHF* on *MHY* were unexpected. Perhaps, families headed by a female householder have greater opportunities for employment in higher income counties whereas in poorer counties there would be few opportunities for employment even at low wages. However, the proportion of female family householders per se is not what is important. Earnings capacity, which has more to do with personal characteristics, and social and economic factors, is what matters. Thus, a priori we cannot claim that *FHHF* should be inversely related to *MHY*.

Note that the proportion of the population 25 years and older with a four year college degree (*POPCD*) was not significant in the *EMP* and *MHY* equations. Human capital theory postulates that entrepreneurship is related to educational attainment and work experience. People with more educational skills tend to form businesses and also have a higher probability of getting better paying jobs. Long periods of lack of economic opportunity in Appalachia, however, have led to the continued outmigration of the more educated and skilled portion of the population. Thus, the insignificant effects of *POPCD* in both the employment and the median household income equations could be an indication of the result of this long term trend.

## 5. SUMMARY AND POLICY IMPLICATIONS

The main objective of this study was to test three hypotheses: (1) Employment, gross inmigration, gross outmigration, and median household income are interdependent and jointly determined by regional covariates. (2) Employment, gross inmigration, gross outmigration, and median household income in one county are conditional on the respective variables in neighboring counties. (3) The existence of dynamic stability or convergence toward long-run equilibrium in the system defines the interdependences among these variables. To test these hypotheses, a spatial simultaneous equations growth equilibrium model was developed. Feasible Generalized Spatial Three-Stage Least Squares (FGS3SLS) estimates of the coefficients of the model parameters were obtained by estimating the model using county-level data covering all 418 Appalachian counties for the 1990–2000. Empirical evidence indicates support for all three hypotheses. In particular, very strong feedback simultaneities are shown among the dependent variables of the model. The results also indicate significant spatial autoregressive lag simultaneities as well as spatial cross-regressive lag simultaneities in all equations of the model. These results indicate that the dependent variable of a given equation in the model is not only conditioned by what is happening in a given county, but by what is happening to the dependent variables in the neighboring counties, as well.

The study results also indicate the presence of spatial correlation in the error terms. This implies that a random shock into the system spreads across the region. A policy implication of these spatial interdependence and significant spatial spillover effects is that neighboring counties may need to pool and integrate their resources to encourage the positive spatial spillover effects and jointly mitigate the negative spatial spillover effects. The speeds of adjustment parameters show the existence of short lag adjustments in the system. These results suggest that dynamic stability exists in the system with respect to the three dependent variables *EMP*, *OTM*, and *MHY*. However, the coefficients for the lagged dependent variables on which the speed of adjustments calculations are based, are significant at levels below 10 percent.

One implication of this research is that regional cooperation between counties is advisable and may even be necessary for successful economic development policies. The multicounty Local Development Districts (LDD), which were established to coordinate and administer programs funded by the Appalachian Regional Commission (ARC), might be able to provide administrative and organizational support for such cooperative efforts. There are 72 LDDs in Appalachia, which means that on average they serve a population of some 33,000 and six counties. The role of the LDDs includes supporting a network of multicounty planning organizations, mostly for infrastructure planning, and they therefore already have the experience and track record of working with different county and local governments. Our results show that neighboring counties can be either competitors or mutually reinforce each other, depending on their specific situation. Because of the fear of competition, and also because of a lack of a history of successful cross-county cooperation, without higher-level government coordination regional cooperation is difficult to achieve, and states need to encourage or create frameworks to make such cooperation possible. The role of the state is particularly important because the results also indicate the presence of agglomeration economies which, combined with the economic weakness of counties with small and dispersed communities, suggests that concentrating public development investments in centers will yield a greater return than treating all locations equally.

During the 1990s, the study period, small business created the vast majority of new jobs, while on balance large employers reduced the number of jobs (Carree and Thurik, 1998, 1999; Wennekers and Thurik, 1999; Audretsch et al., 2000; Acs and Audretsch, 2001; Fritsch and Falck, 2003). Hence, the importance of employment that follows from the results may also suggest something about the importance of small business. However, a conclusive policy recommendation would require additional analysis as our data only include employment level and not about establishments and establishment size.

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