A Spatial Panel Simultaneous-Equations Model of Business Growth, Migration Behavior, Local Public Services and Household Income in Appalachia

Gebremeskel H. Gebremariam, Post-Doctoral Fellow[1]
Tesfa G. Gebremedhin[2]
Peter V. Schaeffer[2]
Tim T. Phipps[2]
Randall W. Jackson[3]

Selected paper prepared for presentation at the annual meeting of the American Agricultural Economic Association in Portland, Oregon, July 29- August 1, 2007.

1. A joint appointment by the Regional Research Institute and Division of Resource Management, West Virginia University, Morgantown, WV 26506.
2. Division of Resource Management, Davis College of Agriculture, Forestry, and Consumer Sciences, P. O. Box 6108, West Virginia University, Morgantown, WV 26506.
3. Regional Research Institute, West Virginia University, P. O. Box 6825, Morgantown, WV26506-6825.

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Abstract: In this paper we develop a spatial panel simultaneous-equations model of business growth, migration behavior, local public services and median household income in a partial lag-adjustment growth-equilibrium framework and utilizing a one-way error component model for the disturbances. This model is an extension of the "jobs follow people or people follow jobs" literature and it improved previous models in the growth-equilibrium tradition by: (1) explicitly modeling local government and regional income in the growth process; (2) explicitly modeling gross in-migration and gross out-migration separately in order to spell out the differential effects, which used to be glossed over under net population change in previous studies; (3) explicitly incorporating both spatially lagged dependent variables and spatially lagged error terms to account for spatial spillover effects in the data set; and (4) extending and generalizing the modeling and estimation of simultaneous systems of spatially interrelated cross sectional equations into a panel data setting. To estimate the model, we develop a five-step new estimation strategy by generalizing the Generalized Spatial Three-Stage Least Squares (GS3SLS) approach outlined in Kelejian and Prucha (2004) into a panel data setting. The empirical implementation of the model uses county-level data from the 418 Appalachian counties for 1980-2000. Generally, the results from these model estimations are consistent with the theoretical expectations and empirical findings in the equilibrium growth literature and provide support to the basic hypotheses of this study. First, the estimates show the existence of *feedback simultaneities* among the endogenous variables of the model. Second, the results also show the existence of conditional convergence with respect to the respective endogenous variable of each equation of the model and the speed of adjustment parameters are generally comparable to those in literature. Third, the results from the parameter estimation of the model indicate the existence of spatial autoregressive lag effects and spatial cross-regressive lag effects with respect to the endogenous variables of the model. One of the key conclusions is that sector specific policies should be integrated and harmonized in order to give the desirable outcome. Besides, regionally focusing resources for development policy may yield greater returns than treating all locations the same.

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1. INTRODUCTION

Parallel to the rapid development of Geographic Information System (GIS) in recent years, a growing body of international research is developing new ways to think about the role of space or geography. Regional disparities have received renewed emphasis in the emerging growth theory and in new economic geography, starting with Romer (1986, 1990), Lucas (1988), and Krugman (1991a). These theories aim at explaining the location behavior of firms and their agglomerative processes. They give several theoretical information and principles that help us understand the uneven spatial repartition of economic activities between regions. The emphasis of the theories of new economic geography upon the effects of the uneven spatial distribution of economic activities on the economic growth of regions led to renewed interest in models of social interaction and dependence among economic agents and spatial spillovers (Anselin, 2002). Thus, decisions and transactions of economic agents may depend upon present and past behavior of neighboring economic agents, which can yield spatial or spatiotemporal dependence.

In the past, models that explicitly incorporate space or geography and therefore applications of spatial econometrics were primarily found in specialized fields such as regional science, urban and real estate economics and economic geography (Anselin, 1998). More recently, however, the technique of spatial econometrics is increasingly being applied in a wide range of empirical investigations in more traditional fields of economics, such as public economics and finance (Case, Rosen and Hines, 1993; Brueckner, 1998), agricultural and environmental economics (Benirschka and Binkley, 1994), labor economics (Topa, 1996). There is also a growing spatial econometric literature that focus on methodological issues that deal with alternative model specifications, test statistics and estimators of models that use spatial data (the literature include, among others, Anselin, 1988,, 1999, 2001, 2003; Anselin and Bera, 1998; Anselin and Kelejian, 1997; Conley, 1999; Driscoll and Kraay, 1998; Elhorst, 2003; Kelejian and Prucha, 1998, 1999, 2002, 2004; Pinkse and Slade, 1998). The development of the spatial econometric techniques further helped researchers to use models that are corrected to misspecifications which result from spatial dependence and heterogeneity. This is significant improvement because spatial dependence, if unaccounted for, can create either inefficient estimates (when the spatial dependence is in the error term) or biased and inconsistent estimates (when the spatial dependence is in the dependent variable). Inefficient regression estimates result when spatial dependence in the error terms is ignored because, in the presence of positive spatial autocorrelation the standard errors of regression are inflated, making the t-values lower and statistical significance more difficult to achieve, and in the presence of negative spatial autocorrelation the standard errors of regression become deflated, giving increased potential for a Type 1 statistical error. When the spatial dependence is in the dependent variable of the model, it is referred as spatial lag and if ignored it leads to biased and inconsistent regression estimates because of omitted variable bias. Ignoring spatial dependence in the dependent variable (spatial lag) is considered to be more serious than ignoring spatial dependence in the error terms (spatial error) (Anselin, 1988). Spatial dependence is particularly problematic in research with politically constructed geographical units of analysis, such as counties (Doreian, 1980; Land and Deane, 1992).

Although advances in spatial econometrics provide researchers with new avenues to address regression problems that are associated with the existence of spatial dependence in regional data sets, most of the applications have been in single-equation frame-works. Yet for many economic problems there are both multiple endogenous variables and data on observations that interact across space. Until recently, researchers have been in the undesirable position of having to choose between modeling spatial interactions in a single equation frame-work, or using multiple equations but losing the advantage of a spatial econometric approach (Rey and Boarnet, 2004). Although not explicitly spatial econometric approach, Steinnes and Fisher's (1974) model of population and employment levels was the first application that tried to incorporate spatial interactions in a simultaneous equations framework. In order to provide some degree of spatial interaction, they included potential variables that aggregated community area population and employment into larger units into their model. This enabled them to express community area population and community area employment as functions of a weighted average of employment in all community areas, and a weighted average of population in all community areas in the data set, respectively. Thus, both population and employment were endogenous variables and by use of lagged population and (instrumented) employment as regressors in the population equation and lagged employment and (instrumented) population in the employment equation, Steinnes and Fisher were able to show the direction of causality between population and employment change. Actually, empirical work on identification of the direction of causality in the 'jobs follow people or people follow jobs' literature and empirical models of small regional development often begin with this two-equation model. Carlino and Mills, 1987 and Dietz, 1998, for example, used this simultaneous system without incorporating spatial effects.

Recognizing the shortcoming of the Carlino-Mills model, Boarnet (1994) proposed a model which integrated the use of potential variables and spatial econometrics in a two-equation model of population and employment growth in New Jersey municipalities. In order to adjust for the difference in the place of residence and the place of work at the community level, he added spatial lags of the endogenous variables to the Carlino-Mills model. Since Boarnet thought that New Jersey municipalities are too small to be their own labor markets, he used a spatial cross-regressive lag model, in the sense that the right-hand side of each equation contains spatial lag of the endogenous variable from the other equation, creating spatial links across equations. Community population change depends on the change in employment aggregated over all communities within commuting distance. In the same token, community employment change depends on population change within commuting distance of the given community.

The Boarnet model was subsequently extended by Henry, Barkley, and Bao (1997) in their efforts to analyze population and employment changes in rural areas and to reveal which kinds of forces are dominant. This model contains interaction terms between urban growth rates and the spatial lag variables as regressors. These linkages enabled them to examine how urban growth affects rural hinterland population and employment change. The parameter estimates on the interaction variables reveal if faster urban growth has a spread or backwash effect on proximate rural communities. Henry et al.(1997) found a mix of spillover and backwash effects from urban core and fringe areas to their rural hinterlands using Southern Functional Economic Areas. Henry, Schmitt, Kristensen, Bakley, and Bao (1999) also extended the work of Henry et al. (1997) by comparing empirical results across three countries (Denmark, France, and the United States) in order to evaluate how country differences in the local socio-economic conditions affect the linkage between urban growth and rural change. Their results indicate that rural population and employment changes in the regions of the three countries under study are sensitive to the performance of the urban core/fringe that is nearby. The general trends that emerge are of urban spread to rural places that have average or large labor market and population.

Henry, Schmitt, and Piguet (2001) also estimated the Carlino and Mills (1987), Boarnet (1994), and the Herny et al. (1997) models for six French regions and compared the results for several related spatial econometric models for the simultaneous equation systems defined in the taxonomy developed in Rey and Boarnet (2004). Their results indicates that adding the spatial cross-regressive terms to the Carlino-Mills model provides an important correction that results in empirical results consistent with the theory in the Carlino-Mills and Boarnet models. Besides, comparing the strength and direction of population effects on employment and vice versa, their results show that people follow jobs in rural France. Moreover, their results suggested general tendency of local spread masking both urban backwash and spread effects, depending on the pattern of urban growth between the core and the fringe.

The limited empirical literature on the efforts to expand these models so that they can incorporate the role of space in explaining variation in economic growth is also mostly limited to cross sectional data only. Spatial panel data models are not very well documented in the spatial econometrics literature (Elhorst, 2003). A second shortcoming of the Carlino-Mills type models as well as their spatial extensions is their assumptions about in-migrants and out-migrants. The endogenous variable “population change” includes both (1) natural population increase and (2) the difference between in-migration and out-migration. Unless the characteristics of in-migrants and out-migrants are assumed to be the same (with respect to their effects to regional economy), taking “population change” as a net figure will gloss over the differential effects of in-migrants and out-migrants. This is even certain for Appalachia where in-migrants and out-migrants are markedly different. Another shortcoming of these models is, although local governments, through their taxation and spending actions, affect the economy and are being affected by it, the role of government is not explicitly captured by these models. The government sector is generally considered exogenous to the system. Besides, the level of per capita regional income is also treated as exogenously determined.

This study develops a methodology that addresses these shortcomings. A five-equation spatial panel simultaneous equations model that explains the interdependences among small business growth, migration behavior, household income, local public services at the county-level is developed in a growth equilibrium framework with the following specifications. First, the model spells out the ‘feed-back simultaneities among these five endogenous variables conditional on a set of regional socio-economic variables. The rationale for this type of modeling is because estimating the coefficients of each equation of the model without considering the feed-backs would lead to biased, inconsistent and inefficient estimates. Consequently, this leads to wrong inferences and policy recommendations.

Second, the model incorporates spatial spillover effects (*spatial autoregressive and spatial cross-regressive lag simultaneities*). When the underlying data generating process includes a spatial dimension, and if the effect is ignored, regression could give inconsistent, inefficient and biased coefficient estimates (see Anselin, 1988, 2001; Anselin Bera, 1998). Thus, the inclusion of spatial effects is important from an econometric perspective. Besides, the inclusion of spatial spillover effects is important from and economic policy perspective because it answers whether and if so to what extent each of the dependent variables of the model in a given county depends on the characteristics of neighboring counties (spatial correlation). Such information is important to design appropriate policies that account for and give room for cross-border effects.

Third, a two-period spatial simultaneous panel data model is developed following a one-way error component model of Baltagi (1995). This is important in the sense that panel data are generally more informative, and they contain more variation and less collinearity among variables. The greater availability of degree of freedom that results from the use of panel data increases estimation efficiency. Specifications of more complicated behavioral relationships that cannot normally be addressed using pure cross-sectional or time-series data are possible with the use of panel data (Elhorst, 2003). Thus, the rationale for the development and implementation of the spatial panel data model is the improvement in the accuracy of hypothesis testing and the subsequent inferences about the interdependences among the core variables of the basic model.

The empirical implementations of these model use data on 418 Appalachian counties for 1980-2000. Although Appalachia is far from being homogenous, the region remains a distinct part of America. Appalachia lags the rest of the nation in every measure of socio-economic indicator. Thus, Appalachia defines a good study area to test the hypotheses set in this study.

2. MODEL DEVELOPMENT

The theoretical base for the interdependencies between population (migration behavior), employment and income is the idea that households and firms are both mobile and that household location decisions maximize utility while firm location decisions maximize profits. That is, households migrate to capture higher wages or income and firms migrate to be near growing consumer markets. These actions in turn generate income to the regional (local) economy. However, according to the principle of utility maximization, household location decisions are expected to be influenced not only by the location of job opportunities and income but also by other factors such as the provision of local public goods and services, social and natural amenities (and disamenities), demographic factors, and regional location. Similarly, the location decisions of firms are expected to be influenced not only by population and income (i.e., growing consumer markets) but also by other factors such as local business climate, wage rates, tax rates, local public services, and regional location. Firm location decisions are also influenced by the substantial financial incentive that local governments offer in an effort to create jobs, spur income growth, and enhance the economic opportunities of the local population. According to the median-voter models of local fiscal behavior, local public expenditures, however, approximate the choices of the utility-maximizing median voter and so depend on income and other revenue sources such as property taxes, income taxes, and factors that determine consumer preferences.

Regional factors that affect households', firms' and local governments' decisions are, however, more likely to exhibit lack of independence in the form of spatial autocorrelation. Spatial autocorrelation or spatial dependence refers to the statistical property where the dependent variable or error term at one location is correlated with observations on the dependent variable or error term at other locations (Anselin, 1988, 2003).

Based upon these assumptions, we construct the following central hypotheses in this research:

1. Business growth, migration behavior, median household income growth and local public expenditures per capita growth rate are interdependent and are jointly determined by county-level variables;
2. Business growth, migration behavior, median household income growth and local public expenditures per capita growth rate in any county are conditional upon initial conditions of that county; and
3. Business growth, migration behavior, median household income growth and local public expenditures per capita growth rate in a county are conditional upon business growth, migration behavior, median household income growth and local public expenditures per capita growth rate in neighboring counties.

To test these hypotheses, we use a spatial simultaneous equations model of business growth, migration behavior, household median income and local public expenditures. Following in the Carlino and Mills tradition and building upon and extending Boarnet (1994), a model that incorporates own-county and neighboring counties effects is specified as follows in matrix notation:

$$\left.\begin{cases}
\mathbf{INM}_t^* = f_1[(\mathbf{OTM}_t^*, \mathbf{\Theta OTM}_t^*), (\mathbf{EMP}_t^*, \mathbf{\Theta EMP}_t^*) \\
\qquad ,(\mathbf{GEX}_t^*, \mathbf{\Theta GEX}_t^*), (\mathbf{MHY}_t^*, \mathbf{\Theta MHY}_t^*), \mathbf{\Theta INM}_t^*, |\mathbf{X}_{t-1}^{in}] \\
\mathbf{OTM}_t^* = f_2[(\mathbf{INM}_t^*, \mathbf{\Theta INM}_t^*), (\mathbf{EMP}_t^*, \mathbf{\Theta EMP}_t^*) \\
\qquad ,(\mathbf{GEX}_t^*, \mathbf{\Theta GEX}_t^*), (\mathbf{MHY}_t^*, \mathbf{\Theta MHY}_t^*), \mathbf{\Theta OTM}_t^*, |\mathbf{X}_{t-1}^{ot}] \\
\mathbf{EMP}_t^* = f_3[(\mathbf{INM}_t^*, \mathbf{\Theta INM}_t^*), (\mathbf{OTM}_t^*, \mathbf{\Theta OTM}_t^*) \\
\qquad ,(\mathbf{GEX}_t^*, \mathbf{\Theta GEX}_t^*), (\mathbf{MHY}_t^*, \mathbf{\Theta MHY}_t^*), \mathbf{\Theta EMP}_t^*, |\mathbf{X}_{t-1}^{em}] \\
\mathbf{GEX}_t^* = f_4[(\mathbf{INM}_t^*, \mathbf{\Theta INM}_t^*), (\mathbf{OTM}_t^*, \mathbf{\Theta OTM}_t^*) \\
\qquad ,(\mathbf{EMP}_t^*, \mathbf{\Theta EMP}_t^*), (\mathbf{MHY}_t^*, \mathbf{\Theta MHY}_t^*), \mathbf{\Theta GEX}_t^*, |\mathbf{X}_{t-1}^{ge}] \\
\mathbf{MHY}_t^* = f_5[(\mathbf{INM}_t^*, \mathbf{\Theta INM}_t^*), (\mathbf{OTM}_t^*, \mathbf{\Theta OTM}_t^*) \\
\qquad ,(\mathbf{EMP}_t^*, \mathbf{\Theta EMP}_t^*), (\mathbf{GEX}_t^*, \mathbf{\Theta GEX}_t^*), \mathbf{\Theta MHY}_t^*, |\mathbf{X}_{t-1}^{mh}]
\end{cases}\right\} \ldots.(1.1) —$$

where $\mathbf{INM}_t^*$, $\mathbf{OTM}_t^*, \mathbf{EMP}_t^*$, $\mathbf{GEX}_t^*$, and $\mathbf{MHY}_t^*$ are of vectors of dimension nT by 1 each of equilibrium levels of gross in-migration, gross out-migration, private non-farm employment, per capita local public expenditures and median household income, respectively, and t indexes time. Here $\mathbf{\Theta}$ is an nT by nT matrix which can be expressed as $\mathbf{\Theta} = (\mathbf{I}_T \otimes \mathbf{W})$ where $\mathbf{I}_T$ denotes identity matrix of dimension T and $\mathbf{W}$ is an n by n spatial weights matrix which can be represented by $\mathbf{W} = \{w_{ij}\}_{i=1, j=1}^{n}$. Each element w_{ij} in $\mathbf{W}$ represents a measure of proximity between observation (location) i and observation (location) j. and according to the adjacency criteria, w_{ij} is equal to one if observation (location) i is adjacent to observation (location) j, and zero otherwise. Hence, $\mathbf{\Theta INM}_t^*$,

$\mathbf{\Theta OTM}_t^*$, $\mathbf{\Theta EMP}_t^*$, $\mathbf{\Theta GEX}_t^*$ and $\mathbf{\Theta MHY}_t^*$ represent the equilibrium values of neighboring counties' effects. The matrices of additional exogenous variables that are included in the respective equations of the system of spatial simultaneous equations are given by $\mathbf{X}_{t-1}^{in}$, $\mathbf{X}_{t-1}^{ot}$, $\mathbf{X}_{t-1}^{em}$, $\mathbf{X}_{t-1}^{ge}$, and $\mathbf{X}_{t-1}^{mh}$, respectively. The descriptions of these variables are given in the data section below. Note that equilibrium levels of gross in-migration, gross out-migration, private non-farm employment per capita local public expenditures and median household income are assumed to be functions of the equilibrium values of the respective right-hand included endogenous variables and their spatial lags, and the actual values of the vectors of the additional exogenous variables.

Based on the result of the PE-test, a multiplicative log-linear form of the model was used. The specification is discussed in greater detail in the section "Estimation Issues." The chosen specification implies a constant-elasticity form for the equilibrium conditions given in (1.1). A log-linear (i.e., log-log) representation of these equilibrium conditions can thus be expressed as:

$$\mathbf{INM}_t^* = \left(\mathbf{OTM}_t^*\right)^{a_1} \times \left(\mathbf{EMP}_t^*\right)^{b_1} \times \left(\mathbf{GEX}_t^*\right)^{c_1} \times \left(\mathbf{MHY}_t^*\right)^{d_1} \times \left(\mathbf{\Theta INM}_t^*\right)^{e_1} \times \left(\mathbf{\Theta OTM}_t^*\right)^{f_1} \times \left(\mathbf{\Theta EMP}_t^*\right)^{g_1} \times \left(\mathbf{\Theta GEX}_t^*\right)^{h_1} \times \left(\mathbf{\Theta MHY}_t^*\right)^{l_1} \times \prod_{k_1=1}^{K_1} \left(\mathbf{X}_{k_1 t-1}^{in}\right)^{x_{1k_1}} \tag{1.2a}$$

$$\mathbf{OTM}_t^* = \left(\mathbf{INM}_t^*\right)^{a_2} \times \left(\mathbf{EMP}_t^*\right)^{b_2} \times \left(\mathbf{GEX}_t^*\right)^{c_2} \times \left(\mathbf{MHY}_t^*\right)^{d_2} \times \left(\mathbf{\Theta OTM}_t^*\right)^{e_2} \times \left(\mathbf{\Theta INM}_t^*\right)^{f_2} \times \left(\mathbf{\Theta EMP}_t^*\right)^{g_2} \times \left(\mathbf{\Theta GEX}_t^*\right)^{h_2} \times \left(\mathbf{\Theta MHY}_t^*\right)^{l_2} \times \prod_{k_2=1}^{K_2} (\mathbf{X}_{k_2 t-1}^{ot})^{x_{2k_2}} \tag{1.2b}$$

$$\mathbf{EMP}_t^* = \left(\mathbf{INM}_t^*\right)^{a_3} \times \left(\mathbf{OTM}_t^*\right)^{b_3} \times \left(\mathbf{GEX}_t^*\right)^{c_3} \times \left(\mathbf{MHY}_t^*\right)^{d_3} \times \left(\mathbf{\Theta EMP}_t^*\right)^{e_3} \times \left(\mathbf{\Theta INM}_t^*\right)^{f_3} \times \left(\mathbf{\Theta OTM}_t^*\right)^{g_3} \times \left(\mathbf{\Theta GEX}_t^*\right)^{h_3} \times \left(\mathbf{\Theta MHY}_t^*\right)^{l_3} \times \prod_{k_3=1}^{K_3} \left(\mathbf{X}_{k_3 t-1}^{em}\right)^{x_{3k_3}} \tag{1.2c}$$

$$\mathbf{GEX}_t^* = \left(\mathbf{INM}_t^*\right)^{a_4} \times \left(\mathbf{OTM}_t^*\right)^{b_4} \times \left(\mathbf{EMP}_t^*\right)^{c_4} \times \left(\mathbf{MHY}_t^*\right)^{d_4} \times \left(\mathbf{\Theta GEX}_t^*\right)^{e_4} \times \left(\mathbf{\Theta INM}_t^*\right)^{f_4}$$

$$\times \left(\mathbf{\Theta OTM}_t^*\right)^{g_4} \times \left(\mathbf{\Theta EMP}_t^*\right)^{h_4} \times \left(\mathbf{\Theta MHY}_t^*\right)^{l_4} \times \prod_{k_4=1}^{K_4} \left(\mathbf{X}_{k_4 t-1}^{em}\right)^{x_{4k_4}} \qquad (1.2d)$$

$$\mathbf{MHY}_t^* = \left(\mathbf{INM}_t^*\right)^{a_5} \times \left(\mathbf{OTM}_t^*\right)^{b_5} \times \left(\mathbf{EMP}_t^*\right)^{c_5} \times \left(\mathbf{GEX}_t^*\right)^{d_5} \times \left(\mathbf{\Theta MHY}_t^*\right)^{e_5} \times \left(\mathbf{\Theta INM}_t^*\right)^{f_5}$$

$$\times \left(\mathbf{\Theta OTM}_t^*\right)^{g_5} \times \left(\mathbf{\Theta EMP}_t^*\right)^{h_5} \times \left(\mathbf{\Theta GEX}_t^*\right)^{l_5} \times \prod_{k_5=1}^{K_5} \left(\mathbf{X}_{k_5 t-1}^{em}\right)^{x_{5k_5}} \qquad (1.2e)$$

where $a_i, b_i, c_i, d_i, e_i, f_i, g_i, h_i$ and l_i i=1,...,5 are the exponents on the endogenous variables and their spatial lags, x_{ik_q} for $i, q = 1,...,5$ are vectors of exponents on the exogenous variables, $\prod$ is the product operator, and K_i for $i = 1,...,5$ are the number of exogenous variables in the gross in-migration, gross out-migration, private non-farm employment, per capita local public expenditures and median household income equations, respectively. The log-linear specification has an advantage of yielding a log-linear reduced form for estimation, where the estimated coefficients represent elasticities. Duffy-Deno (1998) and MacKinnon, White, and Davidson (1983) also show that, compared to a linear specification, a log-linear specification is more appropriate for models involving population and employment densities.

The literature (Edmiston, 2004; Hamalainen and Bockerman, 2004; Aronsson, Lundberg, and Wikstrom, 2001; Deller *et al*., 2001; Henry *et al*., 1999; Duffy-Deno, 1998; Barkley *et al*., 1998; Henry *et al*., 1997; Boarnet, 1994; Duffy, 1994, Carlino and Mills, 1987; Mills and Price, 1984) suggests that employment, population and median household income likely adjust to their equilibrium levels with a substantial lag (i.e., initial conditions). Following the literature a distributed lag adjustment is introduced and the corresponding partial-adjustment process for each of the equations given in (1.1) is of the form:

$$\frac{\mathbf{INM}_t}{\mathbf{INM}_{t-1}} = \left(\frac{\mathbf{INM}_t^*}{\mathbf{INM}_{t-1}}\right)^{\eta_{in}} \rightarrow \ln\left(\mathbf{INM}_t\right) - \ln\left(\mathbf{INM}_{t-1}\right) = \eta_{in}\ln\left(\mathbf{INM}_t^*\right) - \eta_{in}\ln\left(\mathbf{INM}_{t-1}\right) \quad (1.3a)$$

$$\frac{\mathbf{OTM}_t}{\mathbf{OTM}_{t-1}} = \left(\frac{\mathbf{OTM}_t^*}{\mathbf{OTM}_{t-1}}\right)^{\eta_{ot}} \rightarrow \ln\left(\mathbf{OTM}_t\right) - \ln\left(\mathbf{OTM}_{t-1}\right) = \eta_{ot}\ln\left(\mathbf{OTM}_t^*\right) - \eta_{ot}\left(\mathbf{OTM}_{t-1}\right) \quad (1.3b)$$

$$\frac{\mathbf{EMP}_t}{\mathbf{EMP}_{t-1}} = \left(\frac{\mathbf{EMP}_t^*}{\mathbf{EMP}_{t-1}}\right)^{\eta_{em}} \rightarrow \ln\left(\mathbf{EMP}_t\right) - \ln\left(\mathbf{EMP}_{t-1}\right) = \eta_{em}\ln\left(\mathbf{EMP}_t^*\right) - \eta_{em}\left(\mathbf{EMP}_{t-1}\right) \quad (1.3c)$$

$$\frac{\mathbf{GEX}_t}{\mathbf{GEX}_{t-1}} = \left(\frac{\mathbf{GEX}_t^*}{\mathbf{GEX}_{t-1}}\right)^{\eta_{ge}} \rightarrow \ln\left(\mathbf{GEX}_t\right) - \ln\left(\mathbf{GEX}_{t-1}\right) = \eta_{ge}\ln\left(\mathbf{GEX}_t^*\right) - \eta_{ge}\left(\mathbf{GEX}_{t-1}\right) \quad (1.3d)$$

$$\frac{\mathbf{MHY}_t}{\mathbf{MHY}_{t-1}} = \left(\frac{\mathbf{MHY}_t^*}{\mathbf{MHY}_{t-1}}\right)^{\eta_{mh}} \rightarrow \ln\left(\mathbf{MHY}_t\right) - \ln\left(\mathbf{MHY}_{t-1}\right) = \eta_{mh}\ln\left(\mathbf{MHY}_t^*\right) - \eta_{mh}\ln\left(\mathbf{MHY}_{t-1}\right) \quad (1.3e)$$

where the subscript t-1 refers to the indicated variable lagged one period, one decade in this study, and $\eta_{in}, \eta_{ot}, \eta_{em}, \eta_{ge}$, and η_{mh} are the speed of adjustment parameters that represent, respectively, the rate at which in-migration, out-migration, employment, local public expenditure and median household income adjust to their respective desired (steady state) equilibrium levels. They are interpreted as the shares or proportions of the respective equilibrium rate of growth that were realized each period.

Since the model in this study has right-hand side endogenous variables, Moran I test as suggested in Anselin and Kelejian (1997) in models with endogenous regressors was used to detect the existence of spatial dependences in the disturbances. The results of the test show the existence of spatial autoregressive effect in each of the equations of the model. The results are given in Table 3.

Substituting from equations (1.2a) – (1.2e) into equations (1.3a) - (1.3e) to eliminate unknown equilibrium values and simplifying yields:

$$
\begin{aligned}
\mathbf{INMR}_t &= \alpha_1 + \frac{\eta_{in} a_1}{\eta_{ot}} \mathbf{OTMR}_t + \frac{\eta_{in} b_1}{\eta_{em}} \mathbf{EMPR}_t + \frac{\eta_{in} c_1}{\eta_{ge}} \mathbf{GEXR}_t + \frac{\eta_{in} d_1}{\eta_{mh}} \mathbf{MHYR}_t + \frac{\eta_{in} e_1}{\eta_{in}} \left(\mathbf{\Theta INMR}_t \right) \\
&+ \frac{\eta_{in} f_1}{\eta_{ot}} \mathbf{\Theta OTMR}_t + \frac{\eta_{in} g_1}{\eta_{em}} \mathbf{\Theta EMPR}_t + \frac{\eta_{in} h_1}{\eta_{ge}} \mathbf{\Theta GEXR}_t + \frac{\eta_{in} l_1}{\eta_{mh}} \mathbf{\Theta MHYR}_t + \eta_{in} a_1 \ln\left(\mathbf{OTM}_{t-1} \right) \\
&+ \eta_{in} b_1 \ln\left(\mathbf{EMP}_{t-1} \right) + \eta_{in} c_1 \ln\left(\mathbf{GEX}_{t-1} \right) + \eta_{in} d_1 \ln\left(\mathbf{MHY}_{t-1} \right) + \eta_{in} e_1 \ln\left(\mathbf{\Theta INM}_{t-1} \right) \\
&+ \eta_{in} f_1 \ln\left(\mathbf{\Theta OTM}_{t-1} \right) + \eta_{in} g_1 \ln\left(\mathbf{\Theta EMP}_{t-1} \right) + \eta_{in} h_1 \ln\left(\mathbf{\Theta GEX}_{t-1} \right) + \eta_{in} l_1 \ln\left(\mathbf{\Theta MHY}_{t-1} \right) \\
&+ \eta_{in} x_{1k_1} \ln \prod_{k_1=1}^{K_1} \left(\mathbf{X}_{k_1 t-1}^{in} \right) - \eta_{in} \ln\left(\mathbf{INM}_{t-1} \right) + \rho_1 \left(\mathbf{I}_T \otimes \mathbf{W} \right) \mathbf{u}_{\mathrm{t}}^{\mathrm{in}} + \left(\mathbf{I}_{\mathrm{n}} \otimes \boldsymbol{\iota}_T \right) \boldsymbol{\mu}_1 + \boldsymbol{\omega}_{\mathrm{t}}^{\mathrm{in}} \qquad (1.4a)
\end{aligned}
$$

$$
\begin{aligned}
\mathbf{OTMR}_t &= \alpha_2 + \frac{\eta_{ot} a_2}{\eta_{in}} \mathbf{INMR}_t + \frac{\eta_{ot} b_2}{\eta_{em}} \mathbf{EMPR}_t + \frac{\eta_{ot} c_2}{\eta_{ge}} \mathbf{GEXR}_t + \frac{\eta_{ot} d_2}{\eta_{mh}} \mathbf{MHYR}_t + \frac{\eta_{ot} e_2}{\eta_{ot}} \left(\mathbf{\Theta OTMR}_t \right) \\
&+ \frac{\eta_{ot} f_2}{\eta_{in}} \mathbf{\Theta INMR}_t + \frac{\eta_{ot} g_2}{\eta_{em}} \mathbf{\Theta EMPR}_t + \frac{\eta_{ot} h_2}{\eta_{ge}} \mathbf{\Theta GEXR}_t + \frac{\eta_{ot} l_2}{\eta_{mh}} \mathbf{\Theta MHYR}_t + \eta_{ot} a_2 \ln\left(\mathbf{INM}_{t-1} \right) \\
&+ \eta_{ot} b_2 \ln\left(\mathbf{EMP}_{t-1} \right) + \eta_{ot} c_2 \ln\left(\mathbf{GEX}_{t-1} \right) + \eta_{ot} d_2 \ln\left(\mathbf{MHY}_{t-1} \right) + \eta_{ot} e_2 \ln\left(\mathbf{\Theta INM}_{t-1} \right) \\
&+ \eta_{ot} f_2 \ln\left(\mathbf{\Theta OTM}_{t-1} \right) + \eta_{ot} g_2 \ln\left(\mathbf{\Theta EMP}_{t-1} \right) + \eta_{ot} h_2 \ln\left(\mathbf{\Theta GEX}_{t-1} \right) + \eta_{ot} l_2 \ln\left(\mathbf{\Theta MHY}_{t-1} \right) \\
&+ \eta_{ot} x_{2k_2} \ln \prod_{k_2=1}^{K_2} \left(\mathbf{X}_{k_2 t-1}^{ot} \right) - \eta_{ot} \ln\left(\mathbf{OTM}_{t-1} \right) + \rho_2 \left(\mathbf{I}_T \otimes \mathbf{W} \right) \mathbf{u}_{\mathrm{t}}^{\mathrm{ot}} + \left(\mathbf{I}_{\mathrm{n}} \otimes \boldsymbol{\iota}_T \right) \boldsymbol{\mu}_2 + \boldsymbol{\omega}_{\mathrm{t}}^{\mathrm{ot}} \qquad (1.4b)
\end{aligned}
$$

$$
\begin{aligned}
\mathbf{EMPR}_t &= \alpha_3 + \frac{\eta_{em} a_3}{\eta_{in}} \mathbf{INMR}_t + \frac{\eta_{em} b_3}{\eta_{ot}} \mathbf{OTMR}_t + \frac{\eta_{em} c_3}{\eta_{ge}} \mathbf{GEXR}_t + \frac{\eta_{em} d_3}{\eta_{mh}} \mathbf{MHYR}_t + \frac{\eta_{em} e_3}{\eta_{em}} \left(\mathbf{\Theta EMPR}_t \right) \\
&+ \frac{\eta_{em} f_3}{\eta_{in}} \mathbf{\Theta INMR}_t + \frac{\eta_{em} g_3}{\eta_{ot}} \mathbf{\Theta OTMR}_t + \frac{\eta_{em} h_3}{\eta_{ge}} \mathbf{\Theta GEXR}_t + \frac{\eta_{em} l_3}{\eta_{mh}} \mathbf{\Theta MHYR}_t + \eta_{em} a_3 \ln\left(\mathbf{INM}_{t-1} \right) \\
&+ \eta_{em} b_3 \ln\left(\mathbf{OTM}_{t-1} \right) + \eta_{em} c_3 \ln\left(\mathbf{GEX}_{t-1} \right) + \eta_{em} d_3 \ln\left(\mathbf{MHY}_{t-1} \right) + \eta_{em} e_3 \ln\left(\mathbf{\Theta INM}_{t-1} \right) \\
&+ \eta_{em} f_3 \ln\left(\mathbf{\Theta OTM}_{t-1} \right) + \eta_{em} g_3 \ln\left(\mathbf{\Theta EMP}_{t-1} \right) + \eta_{em} h_3 \ln\left(\mathbf{\Theta GEX}_{t-1} \right) + \eta_{em} l_3 \ln\left(\mathbf{\Theta MHY}_{t-1} \right) \\
&+ \eta_{em} x_{3k_3} \ln \prod_{k_3=1}^{K_3} \left(\mathbf{X}_{k_3 t-1}^{em} \right) - \eta_{em} \ln\left(\mathbf{EMP}_{t-1} \right) + \rho_3 \left(\mathbf{I}_T \otimes \mathbf{W} \right) \mathbf{u}_{\mathrm{t}}^{\mathrm{em}} + \left(\mathbf{I}_{\mathrm{n}} \otimes \boldsymbol{\iota}_T \right) \boldsymbol{\mu}_3 + \boldsymbol{\omega}_{\mathrm{t}}^{\mathrm{em}} \qquad (1.4c)
\end{aligned}
$$

$$
\begin{aligned}
\mathbf{GEXR}_t &= \alpha_4 + \frac{\eta_{ge} a_4}{\eta_{in}} \mathbf{INMR}_t + \frac{\eta_{ge} b_4}{\eta_{ot}} \mathbf{OTMR}_t + \frac{\eta_{ge} c_4}{\eta_{em}} \mathbf{EMPR}_t + \frac{\eta_{ge} d_4}{\eta_{mh}} \mathbf{MHYR}_t + \frac{\eta_{ge} e_4}{\eta_{ge}} \left(\mathbf{\Theta GEXR}_t \right) \\
&+ \frac{\eta_{ge} f_4}{\eta_{in}} \mathbf{\Theta INMR}_t + \frac{\eta_{ge} g_4}{\eta_{ot}} \mathbf{\Theta OTMR}_t + \frac{\eta_{ge} h_4}{\eta_{em}} \mathbf{\Theta EMPR}_t + \frac{\eta_{ge} l_4}{\eta_{mh}} \mathbf{\Theta MHYR}_t + \eta_{ge} a_4 \ln\left(\mathbf{INM}_{t-1} \right) \\
&+ \eta_{ge} b_4 \ln\left(\mathbf{OTM}_{t-1} \right) + \eta_{ge} c_4 \ln\left(\mathbf{EMP}_{t-1} \right) + \eta_{ge} d_4 \ln\left(\mathbf{MHY}_{t-1} \right) + \eta_{ge} e_4 \ln\left(\mathbf{\Theta INM}_{t-1} \right) \\
&+ \eta_{ge} f_4 \ln\left(\mathbf{\Theta OTM}_{t-1} \right) + \eta_{ge} g_4 \ln\left(\mathbf{\Theta EMP}_{t-1} \right) + \eta_{ge} h_4 \ln\left(\mathbf{\Theta GEX}_{t-1} \right) + \eta_{ge} l_4 \ln\left(\mathbf{\Theta MHY}_{t-1} \right) \\
&+ \eta_{ge} x_{4k_4} \ln \prod_{k_4=1}^{K_4} \left(\mathbf{X}_{k_4 t-1}^{ge} \right) - \eta_{ge} \ln\left(\mathbf{GEX}_{t-1} \right) + \rho_4 \left(\mathbf{I}_T \otimes \mathbf{W} \right) \mathbf{u}_{\mathrm{t}}^{\mathrm{ge}} + \left(\mathbf{I}_{\mathrm{n}} \otimes \boldsymbol{\iota}_T \right) \boldsymbol{\mu}_4 + \boldsymbol{\omega}_{\mathrm{t}}^{\mathrm{ge}} \qquad (1.4d)
\end{aligned}
$$

$$\begin{aligned}\mathbf{MHYR}_t &= \alpha_5 + \frac{\eta_{mh} a_5}{\eta_{in}} \mathbf{INMR}_t + \frac{\eta_{mh} b_5}{\eta_{ot}} \mathbf{OTMR}_t + \frac{\eta_{mh} c_5}{\eta_{em}} \mathbf{EMPR}_t + \frac{\eta_{mh} d_4}{\eta_{ge}} \mathbf{GEXR}_t + \frac{\eta_{mh} e_5}{\eta_{mh}} \left(\mathbf{\Theta MHYR}_t \right) \\ &+ \frac{\eta_{mh} f_5}{\eta_{in}} \mathbf{\Theta INMR}_t + \frac{\eta_{mh} g_5}{\eta_{ot}} \mathbf{\Theta OTMR}_t + \frac{\eta_{mh} h_5}{\eta_{em}} \mathbf{\Theta EMPR}_t + \frac{\eta_{mh} l_4}{\eta_{ge}} \mathbf{\Theta GEXR}_t + \eta_{mh} a_5 \ln\left(\mathbf{INM}_{t-1}\right) \\ &+ \eta_{mh} b_5 \ln\left(\mathbf{OTM}_{t-1}\right) + \eta_{mh} c_5 \ln\left(\mathbf{EMP}_{t-1}\right) + \eta_{mh} d_5 \ln\left(\mathbf{GEX}_{t-1}\right) + \eta_{mh} e_5 \ln\left(\mathbf{\Theta INM}_{t-1}\right) \\ &+ \eta_{mh} f_5 \ln\left(\mathbf{\Theta OTM}_{t-1}\right) + \eta_{mh} g_5 \ln\left(\mathbf{\Theta EMP}_{t-1}\right) + \eta_{mh} h_5 \ln\left(\mathbf{\Theta GEX}_{t-1}\right) + \eta_{mh} l_5 \ln\left(\mathbf{\Theta MHY}_{t-1}\right) \\ &+ \eta_{mh} x_{5k_5} \ln \prod_{k_5=1}^{K_5} \left(\mathbf{X}_{k_5 t-1}^{ge}\right) - \eta_{mh} \ln\left(\mathbf{MHY}_{t-1}\right) + \rho_5 \left(\mathbf{I}_T \otimes \mathbf{W}\right) \mathbf{u}_{\mathrm{t}}^{\mathrm{mh}} + \left(\mathbf{I}_{\mathrm{n}} \otimes \boldsymbol{\iota}_T\right) \boldsymbol{\mu}_5 + \boldsymbol{\omega}_{\mathrm{t}}^{\mathrm{mh}} \end{aligned} \tag{1.4e}$$

where $\mathbf{INMR}_t, \mathbf{OTMR}_t, \mathbf{EMPR}_t, \mathbf{GEXR}_t$ and $\mathbf{MHYR}_{\mathrm{t}}$ represent the log difference between the end and beginning period values of gross in-migration, gross out-migration, private non-farm employment, local government expenditures per capita, and median household income, respectively. They denote the growth rates of the respective variables. α_j and ρ_j, for $j = 1,...,5$, are unobserved parameters. $\mathbf{I}_T$ and $\mathbf{I}_{\mathrm{n}}$ are identity matrices with dimensions T and n, respectively, $\boldsymbol{\iota}_T$ is a vector of ones of dimension T and $\otimes$ denotes Kronecker product. $\mathbf{u}_t^{in}, \mathbf{u}_t^{ot}, \mathbf{u}_t^{em}, \mathbf{u}_t^{ge}$ and $\mathbf{u}_t^{mh}$ are nT x 1 vectors of disturbances. Following Baltagi (1995) we utilized one-way error component model for the disturbances and the disturbances in jth equation can be given by:

$$\mathbf{u}_j = \mathbf{Z}_\mu \boldsymbol{\mu}_j + \boldsymbol{\omega}_j \tag{1.5}$$

where

$$\mathbf{Z}_\mu = \left(\mathbf{I}_n \otimes \boldsymbol{\iota}_T\right),\ \boldsymbol{\mu}'_j = \left(\mu_{1j}, \mu_{2j}, ..., \mu_{nj}\right),\ \text{and}\ \boldsymbol{\omega}'_j = \left(\omega_{11j}, \omega_{11j}, ..., \omega_{1Tj}, ..., \omega_{n1j}, ..., \omega_{nTj}\right)$$

where $\boldsymbol{\mu}_j$ and $\boldsymbol{\omega}_j$ are random vectors with zero means and covariance matrix:

$$E\begin{pmatrix}\boldsymbol{\mu}_j \\ \boldsymbol{\omega}_j\end{pmatrix}\begin{pmatrix}\boldsymbol{\mu}'_j & \boldsymbol{\omega}_j\end{pmatrix}=\begin{bmatrix}\boldsymbol{\sigma}^2_{\mu_{jj}}\mathbf{I}_n & \mathbf{0} \\ \mathbf{0} & \boldsymbol{\sigma}^2_{\omega_{jj}}\mathbf{I}_{nT}\end{bmatrix}.$$

Thus, the covariance matrix between equations j and l can be given by:

$$\boldsymbol{\Omega}_{jl}=E\left(\mathbf{u}_j\mathbf{u}'_l\right)=\boldsymbol{\sigma}^2_{\mu_{jl}}\left(\mathbf{I}_n\otimes\mathbf{J}_T\right)+\boldsymbol{\sigma}^2_{\omega_{jl}}\left(\mathbf{I}_n\otimes\mathbf{I}_T\right) \tag{1.6}$$

where $\mathbf{J}_T$ is a matrix of ones of dimension T.

In this case, the covariance matrix between the disturbances of different equations has the same one-way error component form. But, there are additional cross equation variances components to be estimated. When one considers the whole model, the variance-covariance matrix for the set of the five structural equations is given by

$$\boldsymbol{\Omega}=E\left(\mathbf{uu}'\right)=\boldsymbol{\Sigma}_\mu\otimes\left(\mathbf{I}_n\otimes\mathbf{J}_T\right)+\boldsymbol{\Sigma}_\omega\otimes\left(\mathbf{I}_n\otimes\mathbf{I}_T\right) \tag{1.7}$$

where $\boldsymbol{\Sigma}_\mu=\left[\boldsymbol{\sigma}^2_{\mu_{jl}}\right]$ and $\boldsymbol{\Sigma}_\omega=\left[\boldsymbol{\sigma}^2_{\omega_{jl}}\right]$ are both 5 x 5 matrices, and $\mathbf{u}'=\left(\mathbf{u}'_1,\mathbf{u}'_2,....,\mathbf{u}'_G\right)$ is a 1 x 5nT vector of disturbances with $\mathbf{u}_j$ defined in equation (1.5) for j = 1,2,…5. Alternatively, by replacing $\mathbf{J}_T$ by $T\bar{\mathbf{J}}_T$ and $\mathbf{I}_T$ by $\mathbf{E}_T+\bar{\mathbf{J}}_T$ where $\mathbf{E}_T$ is by definition $\left(\mathbf{I}_T-\bar{\mathbf{J}}_T\right)$, the variance-covariance matrix can be written as:

$$\begin{aligned}\boldsymbol{\Omega}=E\left(\mathbf{uu}'\right)&=\left(T\boldsymbol{\Sigma}_\mu+\boldsymbol{\Sigma}_\omega\right)\otimes\left(\mathbf{I}_n\otimes\bar{\mathbf{J}}_T\right)+\boldsymbol{\Sigma}_\omega\otimes\left(\mathbf{I}_n\otimes\mathbf{E}_T\right)\\ &=\boldsymbol{\Sigma}_1\otimes\mathbf{P}+\boldsymbol{\Sigma}_\omega\otimes\mathbf{H}\end{aligned} \tag{1.8}$$

where $\boldsymbol{\Sigma}_1=T\boldsymbol{\Sigma}_\mu+\boldsymbol{\Sigma}_\omega$, $\mathbf{P}$ is the matrix which averages the observations across time for each individual and $\mathbf{H}$ is the matrix which obtains the deviations from individual means. Thus,

$$\begin{bmatrix} \mathbf{P} = \mathbf{Z}_\mu \left(\mathbf{Z}'_\mu \mathbf{Z}_\mu \right) \mathbf{Z}'_\mu = \mathbf{I}_n \otimes \overline{\mathbf{J}}_T, \text{ where } \overline{\mathbf{J}}_T = {}^{\mathbf{J}_T}\!/_{T} \\ \mathbf{H} = \mathbf{I}_{nT} - \mathbf{P} = \left(I_T - \frac{J_T}{T} \right) \otimes I_n \end{bmatrix}^{1}.$$

Equation (1.8) is the spectral decomposition of $\boldsymbol{\Omega}$, which means that

$$\boldsymbol{\Omega}^{\mathrm{d}} = \boldsymbol{\Sigma}_1^{\mathrm{d}} \otimes \mathbf{P} + \boldsymbol{\Sigma}_\omega^{\mathrm{d}} \otimes \mathbf{H}$$

where d is an arbitrary scalar. For d=-1/2 one gets

$$\boldsymbol{\Omega}^{-1/2} = \boldsymbol{\Sigma}_1^{-1/2} \otimes \mathbf{P} + \boldsymbol{\Sigma}_\omega^{-1/2} \otimes \mathbf{H} \qquad (1.9)$$

Note that the disturbance vector in the jth equation is generated as:

$$\mathbf{u}_{t,j} = \rho_j \left(\mathbf{I}_T \otimes \mathbf{W} \right) \mathbf{u}_{t,j} + \left(\mathbf{I}_n \otimes \boldsymbol{\iota}_T \right) \boldsymbol{\mu}_j + \boldsymbol{\omega}_{t,j}, \quad \mathrm{j} = 1,...,5 \qquad (1.10)$$

This specification relates the disturbance vector in the jth equation to its own spatial lag. The vectors of innovations ($\boldsymbol{\omega}_{it,j}, \quad \mathrm{j} = 1,...,5$ or $\boldsymbol{\omega}_t^{in}, \boldsymbol{\omega}_t^{ot}, \boldsymbol{\omega}_t^{em}, \boldsymbol{\omega}_t^{ge}$ and $\boldsymbol{\omega}_t^{mh}$) are distributed identically and independently with zero mean and variance covariance equal to $\boldsymbol{\sigma}_{\omega_{jj}}^2 \mathbf{I}_{nT}$, for $\mathrm{j} = 1,...,5$. Hence, they are not spatially correlated. The specification of the mode, however, allows for innovations that correspond to the same cross sectional unit to be correlated across equations. As a result, the vectors of disturbances are spatially correlated across units and across equations.

Equations (1.4a)-(1.4e) constitute a system of simultaneous equations with feedback simultaneity, spatial autoregressive lag simultaneity, spatial cross-regressive lag simultaneity, and spatial autoregressive disturbances. The endogenous variables of the model are $\mathbf{INMR}_t, \mathbf{OTMR}_t, \mathbf{EMPR}_t, \mathbf{GEXR}_t$ and $\mathbf{MHYR}_t$ and if each equation is investigated separately, we notice that each of these variables is expressed in terms of the right hand included endogenous variables and their spatial lags, the logs of the

[1] **P** and **H** are idempotent, orthogonal and sum to the identity matrix.

predetermined (lagged) endogenous variables and their spatial lags, and the logs of other exogenous variables. From equations (1.3a)-(1.3e), however, we see that each of the logs of the predetermined (lagged) endogenous variables is included in the respective endogenous variables. Similarly, it can be shown that each of the spatial lags of the logs of the predetermined (lagged) endogenous variables is included in the spatial lags of the respective endogenous variables. Hence, in order to avoid multicollinearity, the model is estimated by excluding all the predetermined (lagged) endogenous variables, except the own lag, and all the spatial lags of the predetermined (lagged) endogenous variables.

3. DATA TYPE AND SOURCES

The data for the empirical analysis is for all 418 Appalachian counties, which have been collected and compiled 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 Department of Employment Security. County-level data for employment, gross in-migration, gross out-migration, local government expenditures and median household income have been collected for1980, 1990 and 2000. In addition, data for a number of control variables have been collected for 1980 and 1990 from the different sources (see table 1 for the data description).

Dependent Variables

The dependent variables used in the empirical analysis include growth rate of employment, growth rate of gross in-and out-migration, growth rate of median household income and growth rate of per capita direct local government expenditures.

Growth Rate of Employment (EMPR): The growth rate of employment is measured by the log-differences between the 2000 and the 1990 and the1990 and the 1980 levels of private non-farm employments. It is used as a proxy for the growth rate of small business. The justification for this measure is based on the results from empirical studies that indicate that newly created jobs are generated by new businesses that start small (Acs and Audretsch, 2001; Audretsch *et al*., 2000; Carree and Thurik, 1998, 1999; Wennekers and Thurik, 1999; Fritsch and Falck, 2003). Research by the U.S. Small Business Administration also shows that job creation capacity in the U.S. is inversely related to the size of the business. Between 1991 and 1995, for example, the net jobs created in enterprises employing fewer than 500 people was 3.843 million (1-4), 3.446 million (5-19), 2.546 million (20-99), and 1.011 million (100-499), respectively; whereas enterprises employing 500 or more people lost 3.182 million net jobs (U.S. Small Business Administration, 1999).

Growth Rate of Gross In-Migration (INMR): The growth rate of gross in-migration is measured by the log-difference between the levels of gross in-migration into a given county in 2000 and in 1990 and in 1990 and in 1980.

Growth Rate of Gross Out-Migration (OTMR): The growth rate of gross out-migration is measured by the log-difference between the levels of gross out-migration away from a given county in 2000 and in 1990 and in 1990 and in 1980 . The gross in- and gross out-migration variables are used as measures of migration behavior in contrast to the use of net-migration. The use of both gross in-migration and gross out-migration variables is preferable to the use of variable relating to net-migration (see Bowman and Myers (1967) and Sjaastad (1962) for details on this issue). Greenwood (1975) also argued that the use of net-migration concept would involve a substantial loss of information and posses no apparent advantages that cannot also be achieved by regarding the effects of net migration as the sum of the effects of gross in- and gross out-migration. Note that the effects of migration on the sending and on the receiving counties depend critically on the characteristics of the migrants themselves and for any county in-migrants and out-migrants are not likely to have identical characteristics. Moreover, certain variables that are relevant to explaining gross in-migration are not relevant to explaining gross out-migration and the magnitudes of the influence of certain variables on gross in-migration is likely to be different from the magnitudes of these variables on gross out-migration. The models employed in this study attempt to explain the determinants and consequences of gross in- and gross out-migration without the explicit introduction of an individual decision functions. Rather, gross in- and gross out-migration are related to a number of aggregate variables.

Growth Rate of Median Household Income (MHYR): The log-differences between the 1999 and the 1989 and the 1989 and the 1979 levels of median household income in a given county are used to measure the growth rates of median household income. Median household income is used as an average overall measure of county-level income. Median household income is preferable to using the mean or average household income figure, because unlike the mean the median is not influenced by the presence of few extreme values.

Growth Rate of Direct Local Government Expenditures (GEXR): . Local governments spend money on local public services such as education, recreation, police, infrastructure, and others. The total local government expenditures at county-level on local public services divided by the total county population is used as a measure of local public services. The growth rate of direct local government expenditures per capita is measured by the log-differences between the 2002 and the 1992 and the 1992 and the 1982 levels of per capita local government expenditures.

The spatial lag of the Growth Rate of Employment ($\mathbf{\Theta}$ **EMPR**), Growth Rate of Gross In-Migration ($\mathbf{\Theta}$ **INMR**), Growth Rate of Gross Out-Migration ($\mathbf{\Theta}$ **OTMR**), Growth Rate of Median Household Income ($\mathbf{\Theta}$ **MHYR**), and Growth Rate of Direct Local Government Expenditures ($\mathbf{\Theta}$ **GEXR**) are included on the right hand side of each equation of (1.4)-(1.4e). These spatially lagged endogenous variables are created by multiplying each of the dependent variables by $\mathbf{\Theta} = \left(\mathbf{I}_T \otimes \mathbf{W}\right)$ where $\mathbf{I}_\text{T}$ is and identity matrix of dimension T, $\otimes$ is Kronecker product, and **W** is a row standardized queen-based contiguity spatial weights matrix.

Independent Variables

A number of independent variables are used in the empirical analysis. These variables include demographic, human capital, labor market, housing, industry structure, and amenity and policy variables. In line with the literature, unless otherwise indicated, the initial values of the independent variable are used in the analysis. This type of formulation also reduces the problem of endogeneity. All the independent variables are in log form except those that can take negative or zero values. The descriptions of each of the independent variables of the models are given below.

Equations (1.4a) and (1.4b) contain vectors $\mathbf{X}_{k_1 t-1}^{in}$ and $\mathbf{X}_{k_2 t-1}^{ot}$, for $k_1 = 1,...,K_1$, and , $k_2 = 1,...,K_2$ that include exogenous variables, which are believed to affect gross in-migration into and gross out-migration from a county, respectively. These include:

county unemployment rate (UNEMP), county area (AREA), county initial population size (POPs), percentage of owner occupied dwelling (OWHU), median contract rent of housing cost (MCRH), Natural Amenity Index (NAIX)[2], and local public expenditures per capita per unit of personal income tax per capita (EXTAX).

The county unemployment rate (UNEMP) indicates the extent of economic distress in the county and it is expected to exert a negative influence on net migration. POPs is included to account for the positive impacts of the potential spillover effects and good economic opportunities that are associated with larger population areas on migration. OWHU is included to measure community stability and neighborhood quality which are potential attractions to migrants. MCRH is included to account for the potential impacts the cost of renter occupied housing on in-migration. To account for the differential impact of the quality of places on migration behavior, NAIX is included in both equations. How much of the tax paid is put back in the form of local public service may be more important in influencing migration behavior than the absolute amount of tax paid. EXTAX is included in both equations to account for this type of differential effects on migration behavior.

Equation (1.4c) includes a vector of control variables ($\mathbf{X}^{em}_{k_3 t-1}$) for $k_3 = 1,...,K_3$, which consists of, among others, human capital, agglomeration effects, unemployment, and other regional socio-economic variables that are assumed to influence county employment growth (business growth) rate. Human capital is measured as the percentage of adults (over 25 years old) with college degrees and above (POPCD), and the

[2] I use the Natural Amenity Index from http://www.ers.usda.gov/Data/NaturalAmenities/natamenf.xls created by David A. McGranahan (1999) from standardized mean values of climate measures (January temperature, January days of sun, July temperature, and July humidity), topographic variation and water area as proportion of county area.

percentage of adults (over 25 years old) with high school diploma (POPHD) and it is expected that educational attainment is positively associated with employment growth (business growth). To control for agglomeration effects from both the supply and demand sides, the percentage of the population between 25 and 44 of age (POP25-44) is included and it is expected that agglomeration effects to have a positive impact on employment growth (business growth). The proportion of female household header families (FHHF) is included to control for the effect of local labor market characteristics on employment. The county unemployment rate (UNEMP) is also included as a measure of local economic distress. Although a high county unemployment rate is normally associated with a poor economic environment, it may provide an incentive for individuals to form new businesses that can employ not only the owners, but also others. Thus, we don know a priori whether the impact of UNEMP on employment growth is positive or negative. 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. The coefficient on ESBd is expected to be negative. Vector $\mathbf{X}_{k_3t-1}^{em}$ also includes OWHU to capture the effects of the availability of resources to finance businesses and create jobs on employment growth in the county. The percentage of owner-occupied dwellings is expected to be positively associated with employment growth in the county. Also included in $\mathrm{X}_{k_3it-1}^{em}$ are property tax per capita (PCPTAX), percentage of private employment in manufacturing (MANU), percentage of private employment in whole sale and retail trade (WHRT), Social Capital Index (SCIX)[3] , NAIX, and highway density (HWD).

The vector of exogenous variables ($\mathbf{X}^{ge}_{k_4t-1}$), $k_4 = 1,...,K_4$ in equation (1.4d) contains POPs, percentage of school age population (POP5-17), Serious Crime per 100,000 population (SCRM), Direct Federal Expenditure and Grants Per Capita (DFEG), Per Capita Personal Income Tax (PCTAX), Per Capita Long-Term Outstanding Debt (PCLD), and Per Capita Long-Term Debt (LTD).

Equation (1.4e) also contains a vector of exogenous variables ($\mathbf{X}^{mh}_{k_5t-1}, k_5 = 1,...,K_5$), which includes, among others, POPs, POPs^2, FHHF, POPHD, UNEMP, MANU, WHRT, and SCIX.

The initial levels of employment (EMPt-1), gross in-migration (INMt-1), gross out-migration (OTMt-1), median household income (MHYt-1) and direct local government expenditures per capita (GEXt-1) are also included in the respective equations of (1.4a)-(1.4e). These variables are treated as predetermined variables because their values are given at the beginning of each period and hence are not affected by the endogenous variables. Table 1 provides the full list of the endogenous, the spatial lag and control variables, their descriptions and the sources of the data.

4. ESTIMATION ISSUES

To control for unobserved heterogeneity and also to investigate inter-temporal changes, a panel model for two time periods is estimated. Degree of freedom and efficiency

[3] I thank Anil Rupasingha, Stephan J. Goetz and David Freshwater (2006) for allowing me to use their data set on Social Capital Index for U. S. counties. They created a social capital index at the county-level by extracting principal components from associational density (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 non-profit organizations

increases with the use of panel data, because panel data give the advantage of using more informative, more variable, less collinear and large sample size data for estimation. The empirical application of the panel data utilizes a one-way error component model following Baltagi (1995).

Estimating equations (1.4a)-(1.4e) constitute a model with feedback simultaneity, spatial autoregressive lag simultaneity, and spatial cross-regressive lag simultaneity with spatially autoregressive disturbances. This creates a number of complications of which the question of whether or not each equation is identified and the choice of the estimator and instruments are the important ones. As to the question of identification, first, for each equation in the model, I checked that the number of the endogenous variables that appear on the right hand side of the equation is less than the number of control and additional endogenous variables that appear in the model but not in that equation. Second, in the cases where there are more instruments than needed to identify an equation, a test statistic is computed following Hausman (1983)[4] in order to investigate whether the additional instruments are valid in the sense that they are uncorrelated with the error term. That is $E\left(\mathbf{N}'\mathbf{u}_r\right)=0$, where E is the expectation operator and **N** is an instrument matrix as defined below. A fulfillment of this condition ensures that the instrument **N** allows us to identify the regression parameters $\left[\alpha',\beta',\lambda',\gamma'\right]$ of equations (1.4a)-(1.4e), where α' is a vector of slope coefficients and β',λ',γ' are vectors of coefficients on the right–hand side

[4] This test statistic is obtained as nR_u^2, where n is the sample size and R_u^2 is the usual R-squared of the regression of residuals from the second-stage estimation on all included and excluded instruments. In other words, simply estimate equations (1.4a)- (1.4e) by GS2SLS or any efficient limited-information estimator and obtain the resulting residuals, $\hat{u}_r$. Then, regress these on all instruments and calculate nR_u^2. The statistic has a limiting chi-squared distribution with degree of freedom equal to the number of over-identifying restrictions, under the assumed specification of the model.

dependent variables, the spatial lag variables and the predetermined variables, respectively. All the equations of the model are appropriately identified because the hypothesis of orthogonality for each equation cannot be rejected even at p= 0.02 as indicated by the nR_u^2 test statistics in Table 3.

As to the choice of estimator, we prefer Method of Moments approach to that of the maximum likelihood because the latter would involve significant computational complexity[5]. Incidentally, the conventional three-stage least squares estimation to handle the feedback simultaneity would be inappropriate in this context given the spatial autoregressive lag and spatial cross-regressive lag simultaneities terms. The Spatial Generalized Methods of Moments approach followed by Rey and Boarnet (2004) in a Monte Carlo analysis of alternative approaches to modeling spatial simultaneity is also in appropriate given that the model includes spatially autoregressive disturbances.

The increase in the time dimension in the panel data made the estimation programs even more complex. Therefore, we developed a new estimation strategy by generalizing the Generalized Spatial Three-Stage Least Squares (GS3SLS) approach outlined by Kelejian and Prucha (2004) into a panel data setting. This new procedure is done in a five-step routine. In the first step, parameter vector consisting of alphas, betas, lambdas and gammas $[\alpha', \beta', \lambda', \gamma']$ are estimated by Generalized Two-Stage Least Squares (G2SLS) using an instrument matrix **N** that consists of a subset of $\mathbf{X}, \mathbf{\Theta X}, \mathbf{\Theta^2 X}$,

[5] In the maximum likelihood approach, the probability of the joint distribution of all observations is maximized with respect to a number of relevant parameters. This involves, among others, the calculation of the Jacobian determinant that appears in the log-likelihood function, which is computationally intensive, challenging and complex. The complexity even becomes overwhelming if the sample size is large, which is true in this case, and if the spatial weights matrices are not symmetric, which is also true in this case, even if the sample size is moderate (Kelejian and Prucha, 1999, 1998). I do not also expect the error terms in my model to be normally distributed unlike what the maximum-likelihood procedure would require.

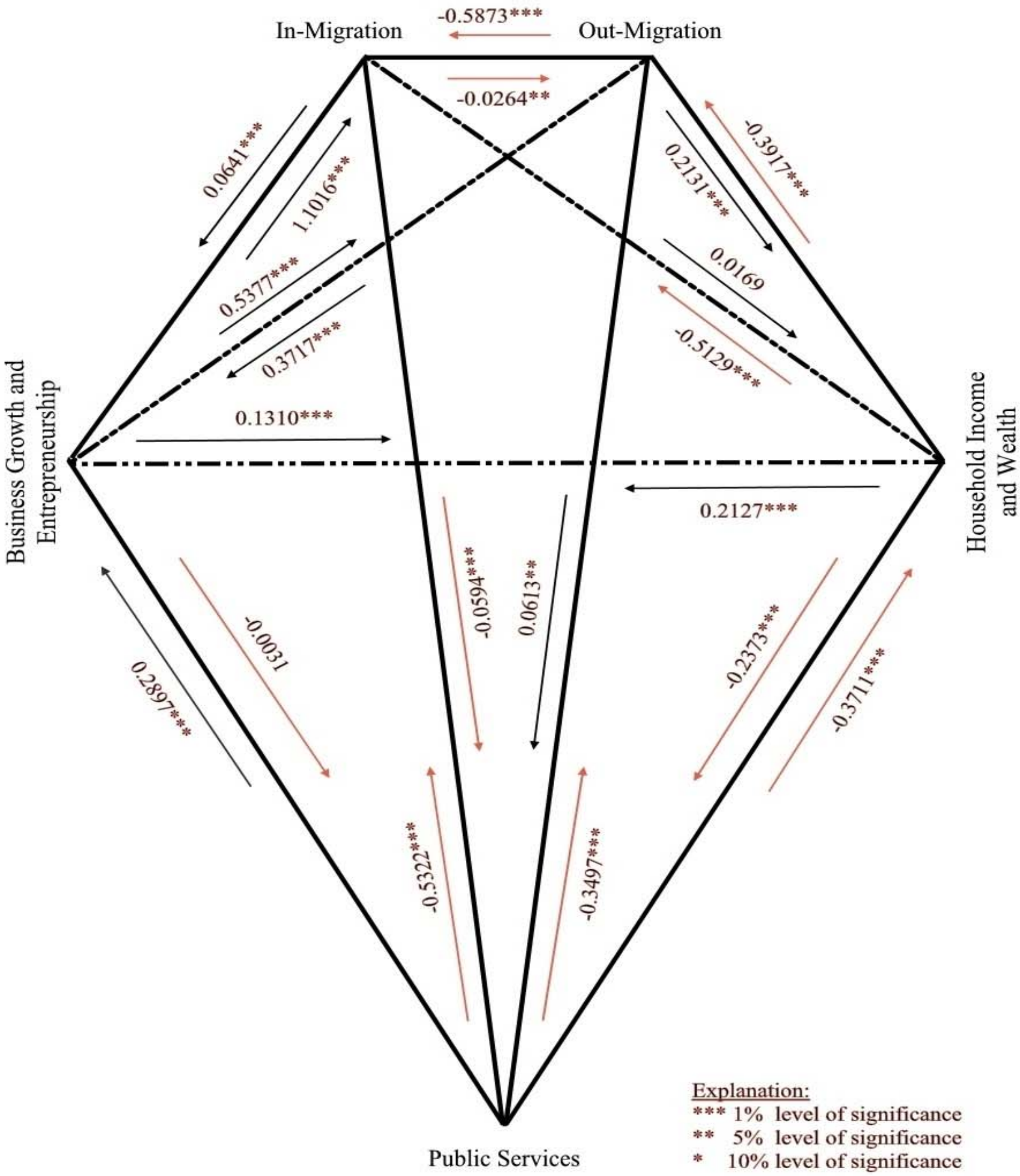
where **X** is the matrix that includes all control variables in the model, and $\mathbf{\Theta} = (\mathbf{I}_T \otimes \mathbf{W})$ where $\mathbf{I}_T$ is and identity matrix of dimension T, $\otimes$ is Kronecker product, and **W** is a row standardized queen-based contiguity spatial weights matrix.

The disturbances for each equation in the model are computed by using the estimates for alphas, betas, lambdas and gammas from the first step. In the second step, first, the program defines two orthogonal and symmetric idempotent matrices, **P** and **H**, where **P** is a matrix which averages the observations across time for each individual and **H** is a matrix which obtains the deviations from the individual means. Then, the computed disturbances from the first step are used to estimate the spatial autoregressive parameter ρ and the variance components σ_w^2 and σ_1^2 using generalized moment procedure suggested by Kapoor, Kelejian and Prucha's (2003). **P** and **H** are used to define the generalized moments estimators of ρ, σ_w^2 and σ_1^2 in terms of six moments conditions. The second step has two parts. In the first part, initial generalized moments estimators of ρ, σ_w^2 and σ_1^2 are computed. These are un-weighted GM estimators. In the second part, weighted GM estimators of ρ, σ_w^2 and σ_1^2 are computed. In the third step, first, the data is transformed (a Cochran-Orcutt-type transformation) using these weighted GM estimators of the spatial autoregressive parameter ρ. Then, the transformed data is further transformed using $\mathbf{\Omega}^{-1/2}$ from equation (1.9) after replacing the variance components σ_w^2 and σ_1^2 by their weighted GM estimators. In the fourth step, Feasible Generalized Spatial Two-Stage Least Squares (FGS2SLS) estimates for alphas, betas, lambdas and gammas are obtained by estimating the transformed model using a subset of the linearly independent columns of $\left[\mathbf{X}, \mathbf{\Theta X}, \mathbf{\Theta}^2\mathbf{X}\right]$ as the instrument matrix. GS2SLS does not, however, utilize the information available across equation because it does not take into account the potential cross equation correlation in the innovation vectors $\boldsymbol{\omega}_{it}^{in}, \boldsymbol{\omega}_{it}^{ot}, \boldsymbol{\omega}_{it}^{em}, \boldsymbol{\omega}_{it}^{ge}$ and $\boldsymbol{\omega}_{it}^{mh}$. The full system information is utilized by stacking the transformed equations (from the third step) in order to estimate them jointly. Thus, in the fifth step the FGS3SLS estimators of alphas, betas, lambdas, and gammas are obtained by estimating this stacked model.

5. RESULTS AND DISCUSSION

Two-period panel data from the 418 Appalachian counties are used for the empirical implementation of the panel model. The FGS3SLS parameter estimates are presented in Table 3. The parameter estimates are mostly consistent with the theoretical expectations. The coefficients on the endogenous variables in all equations of the system, with the exception of the coefficients on **EMPR** in the **GEXR** equation and on **INMR** in the **MHYR** equation, are statistically highly significant. This indicates the existence of very strong *feedback simultaneities* among the dependent variables of the spatial simultaneous equations system (see Figure 1). The results also show strong *spatial autoregressive lag* and *spatial cross-regressive lag simultaneities*. Besides, all of the coefficients on the lagged dependent variables are statistically highly significant, indicating the existence of conditional convergence with respect to each of the endogenous variables conditional on the set of exogenous variables included in each equation of the model. In general, the above three observations support the three basic hypotheses set in this study.

Figure 1*: Feedback Simultaneities* among Small Business Growth, Migration Behavior, Local Public Services and Household Income in Appalachia (1980-2000)



***Employment (Business) Growth Rate*:**

The results in Table 3 indicate that the growth rate of employment (**EMPR**) in a county is strongly dependent on the growth rates of gross in-migration (**INMR**), gross out-migration (**OTMR**), median household income (**MHYR**), and direct local government expenditures (**GEXR**). Each of these variables, with the exception of **GEXR**, in turn, is strongly affected by the growth rate of employment (**EMPR**). The coefficient on **INMR**, for example, is positive and statistically significant at the one percent level. The coefficient on the **EMPR** in the **INMR** equation is also positive and statistically significant at the one percent level. These indicate that counties with high growth rate in gross in-migration are favorable for small business growth and the growth in small business further leads to increases in the growth of gross in-migration into the counties. But note that the attractive effect of business growth (employment) rate is more than the effect of gross in-migration growth rate on employment growth rate as indicated by the level of the coefficients on the respective variables. This is consistent with the Todaro-thesis of rural-urban migration. A single job opening encourages more than one migrant. Similarly, the interdependence between the growth rate of employment and the growth rate of gross out-migration is very strong.

The coefficient on the **OTMR** is positive and statistically significant at the one percent level. The coefficient on **EMPR** in the **OTMR** equation is also positive and statistically significant at the one percent level. This means counties with high rate of growth in out-migration encourage small business growth and small business growth, in turn, encourages out-migration. Now again, the contemporaneous effects of **EMPR** on **OTMR** is stronger than that of **OTMR** on **EMPR** as indicated by their respective coefficients. The results also show strong positive *feedback simultaneity* between **EMPR** and **MHYR**. This is indicated by the positive and statistically significant coefficient on **MHYR** in the **EMPR** equation and the statistically significant coefficient on **EMPR** in the **MHYR** equation. These results suggest that the rate of growth of employment is positively and significantly affected by the rate of growth of median household income (**MHYR**) at the county-level during the study period. This is consistent with economic theory and the literature (Armington and Acs, 2002). Increases in median household income tends to increase regional wealth and as wealth increases consumer demands for goods and services increase. The growth of the market demand in turn encourages small business and firms' formation. Increases in median household income could also lead to capital formation in the form of household savings that finance new firm formation. The formation and expansion of businesses creates employment opportunity and income for the new and the expanding entrepreneurs. These increases in labor and entrepreneurial incomes, in turn, feed *back* into the **MHYR** equation and further leads to an increase in median household income. This is shown by the positive and highly significant coefficient estimate on the **EMPR** in the **MHYR** equation. This interdependence is consistent with economic theory and research results in the literature. Note, however, that the attractive effect of the rate of growth of median household income on the rate of growth of small Business growth (employment) is weaker than that of the rate of growth of small business growth on the rate of growth of median household income.

As expected, the coefficient on the rate of growth in direct local government expenditures in the **EMPR** equation is positive and statistically significant at the one percent level. This result is consistent with the results of many studies, which are summarized in the literature review section of this study, which show that local government expenditures on police, fire protection, water and sanitation infrastructure, school spending, highways, and on public health have positive effects on firm location and business expansion. One also normally expect that the gate of growth in employment to have positive effect on local public services.

To control for the potential effects of spatial spillover effects on the rate of growth of employment, spatial lags of the endogenous variables are included in the **EMPR** equation. The results suggest a negative and significant parameter estimate on the spatial autoregressive lag variable (**Θ EMPR**). This coefficient represents the spatial autoregressive simultaneity and indicates that the growth rate of employment in a given county tends to spillover to neighboring counties and has negative effects on their rates of growth of employment. The results also show a positive and significant parameter estimate on the spatial cross-regressive variable with respect to the rate of growth of gross out-migration (**Θ OTMR**) indicating that an increase in the rate of growth of gross out-migration in neighboring counties tends to encourage business (employment) in a given county. This is possible because the out-migrants from neighboring counties may end up in the county providing the capital and labor that are required for business expansion. The coefficient on **GEXR** is positive and significant at the one percent level. This result suggests that increases in the rate of growth of local government expenditures in neighboring counties tend to increase the rate of growth of employment in a given county. This is possible because government expenditures, for example, in highways, crime protection, pollution control, may have positive cross border effects that could benefit firm location on the other side of the county border.

All these results are important from a policy perspective as they tend to indicate that the growth rate of employment in one county has negative spillover effects to the growth rate of employment in neighboring counties. Counties tend to be in competition in their efforts to encourage business location in their jurisdictions. The results are also important from an economic perspective because the significant spatial autoregressive lag and spatial cross-regressive lags effects indicate that **EMPR** does not only depend on characteristics within the county, but also on that of its neighbors. Hence, spatial effects should be tested for in empirical works involving employment growth rates, growth rate of gross in- and out-migration, growth rate of median household income, as well as growth rates in local government expenditures. The model specification in this study also incorporates spatial autoregressive error component in order to control for the effects of unobservable spatial process (effect) besides the spatial lag in the dependent variables. The results in Table 3 also indicate a positive parameter estimate for rho3 indicating that random shocks into the system with respect to the growth rate of employment do not only affect the county where the shocks originated and its neighbors, but create positive shock waves across Appalachia.

The model in this study includes measure of population statistics such as the percentage of population between 25 and 44 years old (POP25_44) to control for agglomeration effects. The coefficient on POP25-44 is positive and statistically highly significant. The results show that POP25_44 has positive and significant effects on **EMPR**, even after the potential spatial spillover effects are controlled for. This result is consistent with the literature (Acs and Armington, 2004a) which indicates that a growing population increases the demand for consumer goods and services, as well as the pool of potential entrepreneurs which encourage business formation. This result is important from a policy perspective. It indicates that counties with high population concentration are benefiting from the resulting agglomerative and spillover effects that lead to localization of economic activities, in line with Krugman's (1991a, 1991b) argument on regional spillover effects. Consistent with the theoretical expectations, the results also show initial human capital endowment as measured by the percentage of adults (over 25 years old) with college degree (POPCD) is positive and statistically significant at the one percent level. Highly educated people in most case have more access to research and development facilities, and perhaps a good insight to the business world and thus a clear idea about the present and the future needs of the market. As Christensen (2000) contends, entrepreneurs with good education are also more likely to know how to transform innovative ideas into marketable products. Thus, people with more educational attainment tend to establish business, and to be more successful when they do, more often than those with less educational attainments. This result is also consistent with Acs and Armington's (2004b) findings which indicates that the agglomerative effects that contribute to new firm formation could come from the supply factors related to the quality of local labor market and business climate. More educated people would mean more human capital embodied in their general and specific skills, for implementing new ideas for creating and growing new businesses. One possible implication of these findings is that regions or counties with different levels of human capital endowment and different propensities of locally available knowledge to spill over and stimulate new firm formation tend to have different rates of new firm formation, survival and growth. The percent of female householder families (FHHF) is another conditioning demographic variable included in the model. Female householder families tend to have low labor participation rate. The coefficient on FHHF is negative and statistically significant at the one percent level, indicating that FHHF has negative impact on EMPR. This is consistent with theoretical expectations and empirical findings. FHHF affects both the supply-side (as source of labor input) and the demand-side (as source of demand for consumer goods) of the market. Thus, this result suggests that Appalachian counties with higher proportion of female household header in their communities tend to show lower growth in business or employment.

The percentage of people employed in manufacturing (MANU) and the percentage of people employed in whole sale and retail trade (WHRT) are included in the EMPR equation to control for the influence of sectoral concentration of employment on the overall employment of business growth rate. The coefficient on MANU is positive and statistically significant at the one percent level, indicating a direct relationship between growths in overall employment or business expansion and manufacturing employment at the beginning of the periods. The coefficient on WHRT is also positive and significant at the 1 percent level, indicating the positive role played by the service sector in expanding employment and business in Appalachia during the study period. Thus, these results tend to suggest that Appalachian counties who had higher proportion of their labor force employed in manufacturing and whole sale and retail trade at the beginning the periods experienced higher growth rates in overall employment. This is not unrealistic because during most of the study period Appalachia has experienced a shift from coal mining-based economic activities to manufacturing and even more to services. The coefficient on WHRT is higher and even more significant than the coefficient on

MANU in the **EMPR** equation, indicating that the contribution of WHRT to overall employment growth was higher and more sustained than that of MANU. This, in turn may indicate that industrial restructuring might have helped the service sector to grow faster than manufacturing.

The coefficient on the natural amenity index (NAIX) is positive and statistically significant at the one percent level. This result is inconsistent with McGranahan (1999) who found weaker overall association between natural amenities and employment change. High-way density (HWD) is included in the EMPR equation to measure the influence of accessibility to business and employment growth. The positive and statistically significant coefficient on HWD shows a positive association between the concentration of roads and employment growth. This result suggests that Appalachian counties with higher road densities show increases in the growths of employment, compared to counties with low road densities, during the study period. This finding is consistent with both theory and empirical findings (see Carlino and Mills, 1987).

Establishment density (ESBd), which is the total number of private sector establishments in the county divided by the total county's population, is included in our model to capture the degree of competition among firms and crowding of businesses relative to the population. The coefficient on ESBd is negative and statistically significant at the one percent level, indicating that Appalachia region has reached the threshold where competition among firms for consumer demands crowds businesses. According to the results, high ESBd is associated with low growth in Employment (business growth), indicating that firms tend not to locate near each other possibly due to high competition for local demand.

Finally, the elasticity of EMPR with respect to the initial employment level (EMPt-1) is negative and statistically significant indicating convergence in the sense that counties with initial low level of employment at the beginning of the period tend to show higher rate of growth of business than counties with high initial levels of employment conditional on the other explanatory variables in the model. This result supports prior results of rural renaissance in the literature (Deller *et al.*, 2001; Lunderberg, 2003). The speed of adjustment η_{em} is calculated as 0.0873 and it indicates that about 8.73 percent of the equilibrium rate of growth in employment was realized every ten-year period (1980-2000).

Gross In-Migration Growth Rate

The results from the **INMR** equation also indicate that the growth rate of gross in-migration into a county is dependent on the growth rates of employment, gross out-migration, median household income and direct local government expenditures. These interdependences are explained by the statistically significant coefficients on the endogenous variables of the model. Since the interdependence between **EMPR** and **INMR** as well as the implications of this interdependence is explained in the **EMPR** equation above, it is not discussed here. Suffice it to say that the results from this study give support to previous findings from the human-capital-based migration researches where migration is viewed as an investment and that real income and the probability of employment as important determinants of interregional migration (Greenwood and Hunt, 1989; Lundberg, 2003).

The coefficient on **OTMR** in the **INMR** equation is negative and statistically significant at the one percent level. The coefficient on **INMR** in the **OTMR** equation is also negative and statistically significant at the five percent level. These results tend to show that **INMR** and **OTMR** in a given county are inversely related, indicating that counties with high (low) gross in-migration growth rates are also counties with low (high) gross out-migration growth rates. This is consistent with the macroeconomic theory literature where migration is considered as an equilibrating factor in regional labor markets. This is to say that job seekers are expected to move away from high-unemployment regions or counties where they cannot find jobs to low-unemployment regions or counties where the prospects for finding employment are more favorable. This finding implies that the driving force for in-migration into and out-migration from a given county is linked to the labor market characteristics of that county and in-migrant and out-migrants have the same labor market characteristics

The coefficient on the **MHYR** variable in the **INMR** equation is negative and statistically significant at the one percent level. This indicates that gross in-migration growth rate in a given county is negatively and significantly affected by the growth rate of median household income in that county. This is contrary to theoretical expectation where migration is expected to be away from counties with low median household income growth rates to counties with relatively high median household income growth rates. This findings, however, is not unrealistic because it could be due to the fact that some migrant 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. Besides, as Knapp and Graves (1989) suggest, higher income locations may be associated with low amenities that discourage people from migrating in.

Consistent with theoretical expectations, the results in Table 3 also suggest a strong negative interdependence between gross in-migration growth rate (**INMR**) and the growth rate of local public expenditures (**GEXR**). The coefficient on **GEXR** in the **INMR** equation is negative and statistically significant at the one percent level. This result supports previous migration researches in both the Tiebout (1956) and non-Tiebout tradition. Local government expenditures that are financed through higher taxes, particularly property taxes, tend to deter in-migration and encourage out-migration. The property taxes have their deterrent effects on in-migration through changes in employment as discussed above, in reference to the impact of PCPTAX on **EMP**R. Previous studies, for example, by Mead (1982) and Schachter and Athaus (1989) have also generated similar results. The implications of this finding is that many poorer communities in Appalachian region which are forced to levy higher taxes to finance local public services at a certain level would not be able to attract people and even loose people. As the counties/communities continue to loose people, the per capita tax price of local public service for the remaining population increases which further leads to deterioration in the respective communities.

Turning to the spatial autoregressive lag and spatial cross-regressive lag effects, the coefficient on the spatial autoregressive lag variable fails to be significant indicating the absence of spatial autocorrelation with respect to the growth rate of gross in-migration. The coefficient on the spatial cross-regressive lag variables with respect to employment (**Θ EMPR**), however, is positive and statistically significant at the five per cent level. This indicates that the growth rate of gross in-migration into one county is positively associated with the growth rate of employment in neighboring counties. This is very interesting finding because it indicates that people commute to neighboring counties to work. But as people commute to neighboring counties to work, employment/business in those neighboring counties expands and attracts in-migrants. The flow of in-migrants into neighboring counties further leads to business/employment expansion in those counties. Since, as discussed above, the growth rates of employment in neighboring counties are inversely related, the counties whose residents are commuting to the neighboring counties for work, might face a lower growth rate in employment/business. The results in Table 3 also suggest a positive parameter estimate for rho1 indicating that random shocks into the system with respect to gross in-migration growth rate do not only affect the county where the shocks originated and its neighbors, but create positive shock waves across Appalachia.

Population size (POPs) at the initial period has a positive and strong effect on in-migration into a given county. The positive and statistically significant coefficient on POPs is an indication that people migrate to areas (counties) with high concentration of population. Note also that the coefficient on POPs in the out-migration equation is positive and statistically significant at the one per cent level, indicating that counties with high population concentration encourage out-migration and vice versa. These two results suggest that Appalachian counties with higher initial population sizes were both destinations and sources of migrants during the study period.

County unemployment rate (UNEMP) is included in the vector of exogenous variables as a measure of local economic distress. The results suggest that high unemployment rate in a given county is associated with low gross in-migration growth rate in that county. This result is consistent to theoretical expectation and empirical results in the migration literature. Economic theory postulates that job seekers are expected to move from high-unemployment regions where they cannot find a job to low-unemployment regions where the prospects of finding employment are more favorable. Research results from a number of studies have also supported this proposition (Carlino and Mills, 1987; Gabriel et al., 1995; Hunt, 1993; Herzog, Schlottman and Boehm, 1993; Hamalainen and Bockerman, 2004).

The coefficient on the MCRH (Median Contract Rent of Specified Renter-Occupier) is positive and statistically significant at the one percent level. This is not consistent with the theoretical expectations. One would normally expect that an increase in the cost of rental housing to discourage in-migration by increasing the cost of migration. But it is important to look at MCRH as representing both the availability as well as the cost of rental housing. The expectation that increases in the cost of rental housing to discourage in-migration is based on the assumption that enough rental housing is available in all potential in-migration regions. The availability and the cost (affordability) of rental housing have opposing effects on in-migration. The result in this study suggests that the positive effect of availability dominates the negative effect of rental cost. This observation gives support to the results in Hamalainen and Bockerman, (2004) that suggested a lack of rental housing in potential in-migration regions deter out-migration from high unemployment regions.

Consistent with the expectations, the coefficient on the natural amenity index (NAIX) is positive and statistically significant at the five percent level. This result suggests that people tend to move to places high in natural amenities. With increases in per capita incomes, peoples' valuations over local attributes that increase quality of life also tend to increase. The result from this study is also consistent with empirical findings in the compensating differential literature, which indicate that migration to places rich in natural amenities, such as warm winter weather, cooler, less-humid summer weather, etc., have increase over the last several decades (Rappaport, 2004; Blomquist, Berger, and Hooen, 1988).

The coefficient on EXTAX is positive and statistically significant at the one percent level. The EXTAX variable is derived by dividing the per capita local government expenditures by the per capita income taxes. High taxes tend to deter in-migration. But, what might be important determinant of migration behavior is the proportion of the tax which is put back in the form of public services. EXTAX is the amount of local public service per capita that a tax payer would get per unit of income tax he/she pays. Thus, normally, one would expect that high EXTAX would encourage in-migration.

Finally, the coefficient on INMt-1 is negative and statistically significant indicating convergence in the sense that counties with initial low level of in-migration at the beginning of the period tend to show higher rate of growth of **INMR** than counties with high initial gross in-migration conditional on the other explanatory variables in the model. The speed of adjustment η_{in} is calculated as 0.6774 and it indicates that about 67.74 percent of the equilibrium rate of growth in in-migration was realized every ten-year period during (1980-2000).

Gross Out-Migration Growth Rate

The results from the gross out-migration growth rate equation also show very strong interdependences among the endogenous variables of the model. These strong *feed-back* *simultaneities* are indicated by the statistically significant coefficients on the respective endogenous variables. The coefficient on **EMPR**, for example, is positive and statistically significant at the one percent level. The coefficient on **INMR** is negative and statistically significant at the five percent level. The implications of these two results are discussed in the **EMPR** and **INMR** equations, respectively. The results also show negative and statistically significant (both at the one percent level) coefficients on **MHYR** and **GEXR**. A negative and statistically significant coefficient on **MHYR** indicates that Appalachian counties that registered high median household income growth rates tend to experience relatively small gross out-migration growth rates. This is consistent with economic theory and the results of the human capital based migration literature. Economic theory postulates that economic condition affects migration behavior and the relevant income measure for a potential migrant to consider is the present discounted value of his/her stream of expected future returns, both current income level and expected future levels enter into potential migrant's present-value calculation. Thus, areas/counties with relatively high median household income growth rate are expected not only to attract potential in-migrants but also keep potential out-migrants from migrating out. This would imply that counties with relatively high **MHYR** tend to experience lower gross out-migration growth rates, other things remain constant. The result in this study also gives support to Greenwood (1975, 1976) who found that high income localities experienced significantly less gross out-migration.

The negative and statistically significant coefficient on **GEXR** is also an indication that the growth rate of gross out-migration from a given county is inversely related to the growth rate of direct local government expenditures in that county. This is also consistent to economic the expectations of economic theory and empirical findings in the migration literature. Economic theory postulates that migration behavior is affected by the site characteristics of alternative location and that humans migrate in order to consume non-traded goods or location-specific goods such as health care, education, fire protection, crime prevention, etc. Since the provision of such site attributes are associated with the public sector, local government expenditures per capita are likely to provide indicators of the present and the expected future public service levels of a given county. Thus, counties with high rate of growth of direct local government public expenditures are expected to experience small rate of growth of gross out-migration. The result in this study also give support to the findings in Herzog and Schlottmann (1986) which concluded that local government expenditures on education, recreational accessibility and lower tax rates significantly reduce the probability of out-migration.

Turning to the spatial autoregressive lag and spatial cross-regressive lag effects, the coefficient on the spatial autoregressive lag variable is not significant which indicates the absence of spatial autocorrelation with respect to the growth rate of gross out-migration. This suggests that gross out-migration growth rate in one counties has no impact on gross out-migration growth rates in its neighbors. As discussed above, one of the factors that determine gross out-migration growth rate in a given county is its labor market characteristics. No feedback simultaneity between neighboring counties gross out-migration growth rate, therefore, tends to suggest that the economies of Appalachian counties are not integrated as far as their labor markets are concerned. With respect to spatial cross-regressive lags simultaneities, the results, however, show that while **Θ EMPR** and **Θ GEXR** have strong positive effects, **Θ MHYR** had strong negative effect on **OTMR**. The coefficients on **Θ EMPR** and **Θ GEXR**, for example, are positive and statistically significant at the one and five percent levels, respectively. These results are consistent with theoretical expectations and empirical findings. As discussed above, an increase in the employment growth rate in a county induces in-migration to that county by more than the increase in the rate of growth of employment - consistent with Todaro's thesis, which is likely to increase the rate of growth of gross out-migration in neighboring counties. An increase in the rate of growth of direct local government expenditures is also likely to increase the rate of growth of gross out-migration in neighboring counties because people migrate to that county in order to consume the non-traded public goods. Contrary to theoretical expectations, the coefficient on **Θ MHYR** is negative and statistically significant at the one percent level. Macroeconomic theory postulates that humans migrate out from areas with slow rate of growth of median household income/ per capita income to areas with relatively higher rate of growth of income. Accordingly, one would expect that an increase in median household income in neighboring counties to increase the rate of growth of gross out-migration in a given county. The result in this study, however, does not give support to such expectations. One possible reason why this might be so is that potential migrants may still be able to benefit from the increases in neighboring counties' income by commuting a cross county borders.

The results in Table 3 also suggest a positive parameter estimate for rho2 indicating that random shocks into the system with respect to gross out-migration do not only affect the county where the shocks originated and its neighbors, but create positive shock waves across Appalachia.

Similar to the case of in-migration growth rate equation, the coefficients on initial population size (POPs) is positive and statistically significant at the one percent level. This result indicates that counties with high initial population sizes have experienced high gross out-migration growth rates.

The coefficient on UNEMP shows an unanticipated sign and yet statistically significant at the one percent level. Normally, one would expect that people to move away from high-unemployment counties to low-unemployment counties. The result in Table 3, however, suggests that the growth rate of out-migration (**OTMR**) in a given county is negatively associated with the initial level of unemployment in that county. One possible explanation of this observation, similar to what Lansing and Mueller (1967) have argued, is that unemployment tends to be highest in the least mobile groups in the labor force. It should also be noted that prospective unemployment rather than the level of unemployment rate is the major determinant of migration. Besides, the lack of rental housing in the potential in-migration counties/regions could deter out-migration from the high-unemployment counties/regions.

Contrary to theoretical expectations, the coefficient on the NAIX has the wrong sign and yet statically significant at the ten percent level. Normally, one would expect NAIX to have negative influences on **OTMR.** But, it is also important to note that migrants are usually motivated by the altered demand for amenities that are sight-specific. In this respect, amenity data at the county level are highly aggregated and may not reflect the true interdependence between **OTMR** and NAIX.

Finally, the results presented in Table 3 indicate the existence of significant conditional convergence in the out-migration growth rate equation. This is indicated by the negative and statistically significant coefficient on the lagged dependent variable for out-migration (OTMt-1). This result suggests that Appalachian counties with low initial level of out-migration showed higher growths in out-migration growth rates compared to counties with higher initial levels of out-migration, conditional upon the other exogenous variables that are included in the **OTMR** equation. The speed of adjustment η_{ot} is calculated as 0.2836 and it indicates that about 28.36 percent of the equilibrium rate of growth in gross out-migration was realized every ten-year period during (1980-2000).

Median Household Income Growth Rate

The interdependences among the endogenous variable are also witnessed in the **MHYR** equation. The coefficient on **EMPR** is positive and statistically significant at the one percent level, indicating that **MHYR** in a given county is positively and strongly affected by the rate of growth of employment in that county. This is consistent with theoretical expectations. Higher rate of growth of employment means higher employment opportunities, which in turn provide a strong attraction for migrants that leads to net in-migration. The contemporaneous effect with respect to the rate of growth of out-migration on the rate of growth of median household income is also positive and statistically significant at the one percent level. This result suggests that median household income increases with out-migration. This is consistent with theoretical expectations. Migration from or to a given county influences labor demand as well as labor supply in that county. Out-migration from a given county, for example, decreases labor supply in that county, putting upward pressure on wages and incomes in that county, provided labor-demand function is not infinitely elastic. The results in this study also give support to empirical findings in Aronson et al. (2001), which indicate that the out-migration of unemployed persons changes the population composition such that average income increases for a given structure of wage among the employed. This, in turn, would mean that the average income of the out-migrants is lower than the median income of the non-movers. The contemporaneous effect with respect to the growth rate of in-migration on the growth rate of median household income, however, is positive but statistically insignificant. If migrants' endowments of human capital in the form of education, accumulated skills, or entrepreneurial talents are higher compared to the receiving population, then their skills, inventiveness and innovativeness would contribute to local productivity. Migrants may also own physical and financial capital that they may bring with them and invest in the receiving county. Moreover, migrants may contribute to the growth of markets and to the achievement of scale and agglomerations economies. Such demand effects are the sources of growth in per capita personal incomes. The results in this study, however, do not strongly show the existence of such migrant-induced labor demand shifts that offset the migrant-induced labor supply shifts in Appalachian counties during the study period.

Concerning the relationship between the rate of growth of direct local government expenditures and the rate of growth of median household income, the results show that the rate of growth in direct local government expenditures has strong negative impact on the rate of growth of median household income. This is indicated by the negative and statistically significant, at the one percent level, coefficient on **GEXR** in the **MHYR** equation. This may seem to be inconsistent with theoretical expectations. But as discussed elsewhere in this study, the effects of government expenditure depend on the nature/type of that expenditure. Government expenditures on education, health care, fire protection, crime prevention, are more likely to increase labor productivity and hence income. On the other hand, government expenditures on unemployment insurance, welfare payments, etc. have disincentives to work and are more likely to reduce labor productivity and hence income. The results in this study reflect this reality in Appalachia. Traditionally, Appalachia has had higher than average payments from federal assistance programs such as Food Stamps, Social Security Disability Insurance (SSDI), and Temporary Assistance for Needy Families (TANF) and Supplemental Security Income (SSI) (Black and Sanders, 2004). Studies also show that income from Social Security makes up a larger portion of income in Appalachia than in the United States (Thorne, Tickamyer, and Thorne, 2004). Combining these two facts about Appalachia would enable one to suggest that increases in the rate of growth of local government expenditures puts downward pressure on the rate of growth of median household income, by encouraging welfare- recipient induced in-migrations, and by creating disincentive to work among the welfare recipients who have lower levels of median household income. The result in this study is also consistent with empirical findings in Dye (1980), Helms (1985) and Jones (1990) which showed that government expenditures in the form of welfare spending have negative and statistically significant impacts on per capita personal income growth rates.

The results in Table 3 also suggest a positive and statistically significant, at the one percent level, spatial autoregressive lag effect, indicating that the rate of growth of median household income in a given county is positively affected by the rate of growth of median household income in neighboring counties. This strong spatial spillover effect is an indication that there is clustering of counties in Appalachia on the bases of their growth rate of median household incomes. The spatial cross-regressive lag effect with respect to **Θ GEXR** is positive and significant. This is indicated by the positive and statistically significant, at the five percent level, coefficient on **Θ GEXR** in the **Θ MHYR** equation. This result suggests that increases in the rate of growth of local government expenditures in neighboring counties tend to increase the rate of growth of median household income in a given county. This is possible because government expenditures, for example, in highways, crime protection, pollution control, may have positive cross border effects that could benefit residents on the other side of the county border. Since increases in the rate of growth of local government expenditures are associated with increases in the rate of growth of employment or business in the own county, residents from across the border could commute and work in that county. This may increase the average income of those who commute and consequently, the rate of growth of median household income in the sending county (neighboring county) may increase.

As expected, the coefficient on the variable that measures the proportion of the population 25 years and above with high school or above diploma (POPHD) is positive and statistically significant at the one percent level. This implies that Appalachian counties with higher proportion of adult residents with at least high school diplomas at the beginning of the period show subsequent growth in **MHYR**, compared to counties with low initial POPHDs. This result is consistent with the expectations of economic theory as well as with the empirical findings in growth literature. Human capital theory postulates that entrepreneurship is related to educational attainment and work experience. People with more educational attainment tend to found business and also have more probability of getting and securing higher paying jobs. The results in this study are also consistent with the empirical findings in Romer (1986), Lucas (1993), Krugman (1991a), Rauch (1993), Glaeser et al. (1995), Duffy-Deno and Eberts (1991) and Simon and Nardinelli (2002), which indicate that growth in per capita income is associated, one way or the other, with the educational and human capital endowments of a given region/ area.

Although industrial restructuring has led to a shift from manufacturing to service based industries, the process has been low in Appalachia and manufacturing remained as a major source of income compared to service industries. The positive and statistically highly significant coefficient on MANU in the **MHYR** equation supports this assertion. Note, however, that this does not mean that manufacturing remained as a major employer during that period. Actually, as explained above, the declining trend in manufacturing employment is supported by the results of this study.

Finally, the negative and statistically significant coefficient on MHYt-1 is an indication that there was conditional convergence with respect to the rate of growth in median household income in Appalachia during the study period. This means that counties with low initial median household income grew faster than counties with higher initial median household income. The speed of adjustment η_{mh} is calculated as 0.5228 and it indicates that about 52.28 percent of the equilibrium rate of growth in median household income was realized every ten-year period during (1980-2000).

Direct Government Expenditures Growth Rate

Similar to what we have in the other equations, the estimates from the **GEXR** equation show the existence of significant feed-back simultaneity. Three of the endogenous variables have statistically significant effect on the growth rate of direct local government expenditures per capita. The contemporaneous effect with respect to the rate of growth of out-migration (**OTMR**) on the rate of growth of direct local government expenditures per capita, for example, is positive and statistically significant at the one percent level. This result indicates that high growth rate in direct local government expenditures per capita is positively associated with high growth rate of gross out-migration which is consistent with the expectation of economic theory. Migrants have important impacts on the demand of locally provided public goods and services as well as on the revenue that support the provision of these public goods and services by changing the size and the density of population of a region or a county. Out-migration reduces the possibility of gaining economies of scale in the provision of public services. Excessive out-migration creates excess capacity and very high costs of maintaining overstock of public infrastructure, such as schools, police facilities, fire protection, etc., in the area of origin. The contemporaneous effect with respect to the growth rate of in-migration (**INMR**) on the growth rate of direct local government expenditures per capita is negative and statistically significant at the one percent level. This result indicates that the growth rate of direct local government expenditures per capita in a given county is negatively associated with the growth rate of in-migration to that county. One possible explanation for this observation is that in-migration may lead to increase in population and its density in the receiving region that enable local government to realize the advantages of economies of scale in the provision of public services. In that case, although total local government expenditures may increase, per capita could still decline if the advantages of economies of scale are realized.

The coefficient on **MHYR** is negative and statistically significant at the one percent level. This result is not consistent with theoretical expectations. Increases in per capita income provide local governments with more tax revenues that support the provision of more public goods and services, which in turn lead to higher local public expenditures. In the context of Appalachia, the result from this study is not unrealistic. As discussed in the subsection on 'Median Household Income Growth Rate', to the extent welfare payments constitute the biggest of local government expenditures in Appalachia, increases in the rates of growth of median household incomes are expected to lead to decreases in the rates of direct local government expenditures.

As expected, the results in Table 3 also show the existence of strong and positive spatial autoregressive lag effect with respect to **GEXR**, as indicated by the positive and statistically significant, at the one percent level, coefficient on **Θ GEXR** in the **GEXR** equation. This result shows that the rate of growth of direct local government expenditures in a given county is positively associated with the rates of growth of direct local government expenditures in neighboring counties. These interdependences could arise because (1) local governments may finance public spending through a tax on mobile capital and since the level of tax base in a jurisdiction depends both on own and on other jurisdictions' tax rates, strategic interaction results; (2) beneficial or harmful effects could spill over onto residents of neighboring counties from expenditures on local public services in a given count; and (3) imperfectly informed voters in a given county use the performance of other governments as a yardstick to evaluate their own governments, which , in turn, lead to local governments to react to the action of their neighbors, resulting in local governments mimicking each others' behavior. The result in this study gives support to the findings in Case, Hines and Rosen (1993), Kelejian and Robinson (1993), and Besley and Case (1995) which indicate public expenditures in a given county is positively and significantly affected by public expenditures in neighboring counties.

The results in Table 3 also suggest a negative parameter estimate for rho4 indicating that random shocks into the system with respect to direct local government expenditures per capita do not only affect the county where the shocks originated and its neighbors, but create negative shock waves across Appalachia.

The proportion of school age population denoted by POP5-17 is included in the model to control for the differential impact of population age structure on local government expenditures. As expected, the coefficient on POP5-17 is positive and statistically significant. Increases in the proportion of school age population create pressure for increases in local spending on education, in the form of expanding services and cost of expanding capacity. The results in this study are also consistent with the empirical findings in Marlow and Shiers (1999) and Alhin and Johansson (2001) which indicate that an increase in the proportion of young people generates pressure for increases in public spending in education.

As expected, the coefficients on DFEG (direct federal expenditures and grants per capita), and PCTAX (per capita income tax per capita) and LTD (long-term debt per capita) are all positive and statistically significant at the one level. Since both DFEG is one of the components of local government revenue, it is expected to have positive effects on the rate of growth of direct local government expenditures per capita. Thus, the results in this study are consistent with the expectations of economic intuition. The results also give support to empirical finding in Fisher and Navin (1992) and Henderson (1968) which show that local public expenditure per capita is positively related to grants in-aid per capita from higher governments. Similarly, since PCTAX is also one of the components of local government the revenue, increases in PCTAX would provide local government with more money to spend on local public services. To control for the impacts of the ability of local government to borrow from external sources in order to finance the provision of local public services, LTD (Long-Term Debt per capita) is also included in the model. A positive and significant coefficient on LTD means, local governments in Appalachian counties were not constrained in their capacity to borrow from external sources in order to finance local public services. Note, however, that since the coefficient is small, the net positive effect may not be big.

The coefficient on PCTD (total debt outstanding per capita) is negative and statistically significant at the one percent level. This result is consistent with theoretical expectations in that the amount of total debt outstanding accumulated constrains local governments their capacity to further borrow apart from their obligation to pay their debts now. The effect would be to decreases in local public expenditures, but since the coefficient is small, the net impact may not be large.

Finally, the negative and statistically significant coefficient on DGEXt-1 is an indication that there was conditional convergence with respect to the rate of growth in direct local government expenditures in Appalachia during the study period. This means that counties with low initial direct local government expenditures had higher growth in direct local government expenditures than counties with higher initial direct local government expenditures. The speed of adjustment η_{ge} is calculated as 0.2771 and it indicates that about 27.71 percent of the equilibrium rate of growth in local public expenditures was realized every ten-year period during (1980-2000).

6. CONCLUDING SUMMARIES

Generally, the results from these model estimations are consistent with the theoretical expectations and empirical findings in the equilibrium growth literature and provide support to the basic hypotheses of this study. First, the parameter estimates showed the existence of *feedback simultaneities* among the endogenous variables of the models. The coefficients on the endogenous variables in almost all equations of the model are statistically significant at least at the five percent levels. This indicates that the interdependences among employment growth rate, gross in-migration growth rate, gross out-migration growth rate, median household income growth rate and direct local government expenditures growth rate are very strong. The directions of causation as indicated by the signs of the coefficients are also consistent with the theoretical expectations.

Second, the results also showed the existence of conditional convergence with respect to the respective endogenous variable of each equation of the models. This is indicated by the negative and statistically highly significant coefficients on the lagged dependent variables of the models. This implied that the rates of growth of employment, gross in-migration, gross out-migration, median household income and direct local government expenditures were higher in counties that had low initial levels of employment, gross in-migration, gross out-migration, median household income and direct local government expenditures, respectively compared to counties with high initial levels of the same.

Third, the results indicated the existence of spatial autoregressive lag effects and spatial cross-regressive lag effects with respect to the endogenous variables of the model. Besides, results for Global Moran's I statistics indicated the existence of spatial spillover effect with respect to the error terms of the spatial panel model. These results would imply that employment growth rate, gross in-migration growth rate, gross out-migration growth rate, median household income growth rate, and direct local government growth rate in a given county are dependent on the averages of employment growth rates, gross in-migration growth rates, gross in-migration growth rates, median household income growth rates, and direct local government growth rate of neighboring counties in the study area. These results are also important from the economic and policy perspectives because they indicate that each of the dependent variables in the model is not only dependent on the characteristics of that county but also on the characteristics of those of its neighbors. Thus, spatial effects should be tested for in empirical works involving **EMPR**, **INMR**, **OTMR**, **MHYR** and **GEXR**. The existence of spatial dependences in the error terms is an indication that random shocks into the system with respect to each of these endogenous variables do not only affect the county/counties where the shock originated and its/their neighbors, but also create shocks waves across the study area (Appalachia). This is possible because of the structure of the autoregressive error model.

In the growth rate of employment (**EMPR**) equation, **EMPR** is positively associated with the growth rates of gross in-migration, gross out-migration, median household income and direct local government expenditures. This is consistent with the theoretical expectations in that (1) in-migrants could be the sources of labor and capital for business expansion and hence employment; (2) increase in median household income could be the source of demand for new businesses and business expiation; (3) direct local government expenditures in the form of highways, crime protection, schools, and on public health could have positive effects on firm location and business expansion; and (4) a positive effect of the growth rate of gross out-migration on **EMPR** is possible because since **OTMR** is positively and highly associated with county-population size, **OTMR** might pick up the effect of population size on employment. The results also suggested a negative autoregressive lag effect indicating the growth rate of employment in a certain county tends to spillover to neighboring counties and has negative effects on their growth rates of employment. This could happen because of the competition for consumer demand. This conclusion is also supported by the negative and statistically significant coefficient on ESBd (total number of establishments per capita) variable, which indicates that Appalachian region has reached the threshold where competition among firms for consumer demands crowds businesses. The negative spatial autoregressive lag effect indicates that the competition is not confined to the home county only. Access to shopping centers across county borders makes this possibility an empirical reality.

The results from the **EMPR** equation also showed that growth rate of employment in a given county is positively and highly associated with the initial levels of the proportion adult population between 25 and 44 years of age (POP25-44), the percentage of adult population with a college degree (POPCD), the proportion of civilian labor force employed in manufacturing (MANU), the proportion of the civilian labor force employed in wholesale and retail trade (WHRT), natural amenity index (NAIX), and county high way density (HWD). All these results are consistent with the theoretical expectation and empirical findings. The impact of POP25-44 associated with the agglomerative effect of population on business growth. Educational attainment is also positively associated with business growth because more educated people tend to have more access to research and development facilities, good insights to the business world and thus clear ideas about the present and the future needs of the market, which in turn enable them to establish businesses and to be successful when they do. Besides, more educated people would mean more human capital embodied in their general and specific skills, for implementing new ideas, for creating and growing new businesses. These results would suggest that Appalachian region or counties with different levels of human capital endowment and different propensities of locally available knowledge to spill over and stimulate new firm formation tend to have different rates of new firm formation, survival and growth. Although both MANU and WHRT showed positive effect on the growth rate of employment of a given county, considering their coefficients and the associated levels of significances, WHRT had more impact than MANU did. These results, nonetheless, indicate that Appalachia had experienced a shift from coal mining-based economic activities to manufacturing and even more to service-based economic activities during the study periods. These results also suggest that the contribution of WHRT to the overall growth rate of employment was higher and more sustained than MANU did.

Although road quality differences are not accounted for in this study, the results indicated that increases in road density had positive and significant impacts on the growth rate of employment. Transportation is a critical bottle neck in the growth and development of business activities in a given area. Cost reduction as the result of the availability of roads and the increase in consumer demand that results from increased access to shopping centers boosts businesses.

Consistent with the theoretical expectations and empirical findings, the coefficient on FHHF is negative and statistically significant at the one percent level, indicating that FHHF is negatively associated with EMPR. Thus, this result suggests that Appalachian counties with higher proportion of female household header families in their communities tended to show low growth in business or employment during the study periods. Female householder families tend to have low human capital, low income and low labor participation rate. Hence, FHHF affects both the supply-side (as source of labor input) and the demand-side (as source of demand for consumer goods) of the market.

Turning to the growth rate of gross in- migration equation, the results showed that the growth rate of gross in-migration in a given county is positively associated with the growth rate of employment in that county. Further inspection of the results showed that the attractive affects of **EMPR** on **INMR** are stronger than the effects of **INMR** on **EMPR** creating a Todaro type migration pattern: The coefficient on **EMPR** in the **INMR** equation is greater than one which indicates that a single job opening tended to lead to more than one in-migrant., holding other things to remain constant..

The results also indicated that there existed a strong inverse relationship between the growth rate of gross in-migration and the growth rate of gross out-migration in Appalachian counties during the study periods. This would mean that job seekers in Appalachia move away from high-unemployment counties where they cannot find jobs to low-unemployment counties where the prospect for finding employment are more favorable. This finding implies that the driving force for in-migration into and out-migration from a given county is linked to the labor market characteristics of that county and in-migrant and out-migrants have the same labor market characteristics. Thus, migration acted as an equilibrating factor in Appalachia labor markets during the study periods.

The negative coefficients on the growth rate of median household income and the growth rate of direct local government expenditures per capita in the growth rate of gross in-migration equation indicate that in-migrants tended to prefer low-income and low-tax counties. Since low-income counties, however, has high propensities to levy high taxes in order to finance local public services at certain levels, the net effect depends upon the respective strengths of the marginal effects.

With respect to spatial spillover effects, the results indicated that the growth rate of gross in-migration into one county is positively associated with the growth rate of employment in neighboring counties. This finding indicates that people commute to neighboring counties to work, but as people commute to neighboring counties to work, employment/business in those neighboring counties expands and attracts in-migrants. The flow of in-migrants into neighboring counties further leads to business/employment expansion in those counties. Since, as discussed above, the growth rates of employment in neighboring counties are inversely related, the counties whose residents are commuting to the neighboring counties for work, might face a lower growth rate in employment/business.

Concerning the effects of exogenous variable on the growth rate of gross in-migration, the results showed that INMR is positively associated with the initial county population size (POPs), the median cost of renter occupied housing (MCRH), natural amenity index (NAIX), and the amount of local public expenditures per unit of income tax per capita (EXTAX). All these results except for MCRH are consistent with the theoretical expectations. The positive effects of population size are through its agglomerative effects that create favorable conditions for business expansion and employment, which, in turn, attract in-migrants. The positive effect of NAIX is an indication that amenity based migrations are important in Appalachia during the study periods. The positive effect of EXTAX is also an indication that tax payers are more responsive to the amount of local public services per capita that they could get for every unit income tax they pay in Appalachia during the study periods. Finally, the positive effects of MCRH indicate that the positive effects of the availability of housing dominate the negative effects of the cost of rental housing in the migration potential destination counties. The negative effects of county unemployment rate on the growth rate of gross in-migration that this study showed is also consistent with the expectations of economic theory. Regional UNEMP represents a slack labor market and deters in-migration. Thus, Appalachian counties with high initial UNEMP experienced lower growth rate of in-migration during the study periods and vice versa.

The coefficients on the variables in the growth rate of gross out-migration equation were also mostly consistent with the theoretical expectations. The negative coefficient on **MHYR** indicates that counties with high growth rate of median household income more likely to experience lower growth rate of gross out-migration, consistent with the human capital-based migration literature. The negative coefficient on **GEXR** also indicates that counties with high growth rate of direct local government expenditures per capita are more likely to experience low growth rate of gross out-migration. Thus, Appalachian counties with high local government expenditures per capita, especially on location-specific public goods such as health care, education, fire protection, etc., are more likely to keep potential out-migrants from migrating.

Concerning the spatial autoregressive and cross-regressive lags effects, the results indicated absence of spatial autoregressive lag effect and positive spatial cross-regressive lags effects with respect to **Θ EMPR** and **Θ GEXR** and negative spatial cross-regressive lag effect with respect to **Θ MHYR**. The absence of spatial autoregressive lag effects in both the **INMR** and **OTMR** equations suggests that the economies of Appalachian counties were not strongly integrated as far as their labor markets are concerned. The positive coefficients on **Θ EMPR** and **Θ GEXR** indicate that counties surrounded by counties with high growth rates of employment and direct local government expenditures per capita are more likely to experience high growth rates of gross out-migration. The negative coefficient on **Θ MHYR**, on the other hand, is an indication that potential out-migrants from a given county benefit from the increases in neighboring counties' incomes by commuting across the county's borders.

The results from the median household income (**MHYR**) equation are also mostly consistent with the theoretical expectations. The results showed that counties with higher growth rate of employment are more likely to experience higher growth rates of median household incomes. This means that the average payments for the new jobs in a given county are more than the median household income. The results also showed that counties with higher growth rates of out-migration had higher growth rates of median household income. This is possible because out-migration from a given county tends to decrease labor supply in that county, putting an upward pressure on wages and incomes in that county. The negative coefficient on **GEX**R in the **MHYR** equation is an indication that direct local government expenditures per capita in Appalachia are mostly concentrated on non-labor productivity enhancing expenditures such as welfare and unemployment insurance payments.

The positive coefficient on the spatial lag variable (**Θ MHYR**) indicates that there are clustering of counties in Appalachia on the bases of their growth rates of median household incomes. The results from the exploratory spatial data analysis (not shown in this study) also showed most of the low income counties are clustered in Central Appalachia, whereas the high income counties are clustered, mostly around big cites, in the Northern and Southern Appalachia sub regions. The results also showed that the growth rate of direct local government expenditures per capita (**GEXR**) had positive spatial cross-regressive lag effects on the growth rates of median household income in Appalachian counties during the study periods. This is possible because government expenditures, for example, in highways, crime protection, pollution control, may have positive cross border effects that could benefit residents on the other side of the county border. Since increases in the rate of growth of local government expenditures are associated with increases in the rate of growth of employment or business in own county, residents from across the border could commute and work in that county. This may increase the average income of those who commute and consequently, the rate of growth of median household income in the sending county (neighboring county) may increase.

The results from the **MHYR** equation also indicated that Appalachian counties with high proportion of adult residents with at least high school diplomas at the beginning of the period show subsequent growth in **MHYR**, compared to counties with low initial

POPHDs. This implies that people with more educational attainment tend to establish business and also have more probability of getting and securing higher paying jobs.

The results from **GEXR** equation are also mostly consistent with the theoretical expectations. The results indicated that high growth rate of direct local government expenditures per capita is positively associated with high growth rate of gross out-migration. This is possible because migrants have important impacts on the demand of locally provided public goods and services as well as on the revenue that support the provision of these public goods and services by changing the size and the density of population of a region or a county. Out-migration reduces the possibility of gaining economies of scale in the provision of public services. Excessive out-migration creates excess capacity and very high costs of maintaining overstock of public infrastructure, such as schools, police facilities, fire protection, etc., in the area of origin.

The results also indicate that the growth rate of direct local government expenditures per capita in a given county is negatively associated with the growth rate of gross in-migration into that county. One possible explanation for this observation is that in-migration may lead to increase in population and its density in the receiving region that enable local government to realize the advantages of economies of scale in the provision of public services. In that case, although total local government expenditures may increase, per capita could still decline if the advantages of economies of scale are realized.

The negative coefficient on **MHYR** in the **GEXR** equation indicates that Appalachian counties with high growth rates in median household income are more likely to experience low growth of direct local government expenditure per capita. This is realistic for Appalachia because welfare payments constitute the biggest share of local government expenditures of Appalachia counties.

Concerning the spatial autoregressive lag effect, the result shows that the rate of growth of direct local government expenditures in a given county is positively associated with the rates of growth of direct local government expenditures in neighboring counties. These interdependences could arise because (1) local governments may finance public spending through a tax on mobile capital and since the level of tax base in a jurisdiction depends both on own and on other jurisdictions' tax rates, strategic interaction results; (2) beneficial or harmful effects could spill over onto residents of neighboring counties from expenditures on local public services in a given count; and (3) imperfectly informed voters in a given county use the performance of other governments as a yardstick to evaluate their own governments, which, in turn, lead to local governments to react to the action of their neighbors, resulting in local governments mimicking each others' behavior.

7. POLICY IMPLICATIONS

The empirical findings in this study suggested the existence of significant *feedback simultaneities* among the growth rates of employment, gross in-migration, gross out-migration, median household income, and direct local government expenditures per capita in Appalachian counties during the study periods. This finding is important from economic policy perspective because it indicates that sector specific policies should be integrated and harmonized in order to achieve the desirable outcome. Under this circumstance, looking at the direct impact of a change in a given policy can not tell the whole story. What is more important is the total (direct plus indirect) impact of a change in a given policy.

The results in this study also showed the existence of spatial autoregressive lag and cross-regressive lag simultaneities among the data set with respect to the growth rates of employment, gross in-migration, gross out-migration, median household income, and direct local government expenditures per capita. These findings are also important from an economic perspective because the existence of these spatial lag effects indicates that the growth rates of employment, gross in-migration, gross out-migration, median household income, and direct local government expenditures per capita in a given county are not only dependent on the characteristics of that county, but also on that of its neighbors. This further indicates for the need to do spatial effect tests in empirical research works involving the growth rates of employment, gross in-migration, gross out-migration, median household income, and direct local government expenditures per capita. These findings are also important from a policy perspective as they indicate cross-county interdependences among the growth equilibrium model endogenous variables which would necessitate economic development policy coordination at the regional level. A region, here, could be a group of counties with similar socio-economic conditions or the whole Appalachia region. Poverty reduction policies, for example, may be better coordinated among counties in Central Appalachia, where there is high concentration of poverty compared to the other sub-regions. But it is also important to note that the whole Appalachia may be affected by the ripple effect- a neighbor of my neighbor type. The weights matrix is designed to account for these types of effects.

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Table 1: Variable Description and Data Sources

Variable Code	Variable Description	Source
Endogenous Variables		
EMPR	Growth Rate of Employment, 1980-1990,1990-2000	Computed
INMR	Growth Rate of Gross In-Migration, 1980-1990, 1990-2000	Computed
OTMR	Growth Rate of Gross Out-Migration, 1980-1990,1990-2000	Computed
MHYR	Growth Rate of Median Household Income, 1979-1989,1989-1999	Computed
GEXR	Growth Rate of Local Public Expenditures Per Capita, 1982-1992,1992-2002	Computed
Spatially lagged Endogenous Variables		
Θ EMPR	Spatial Lag of EMPR	Computed
Θ INMR	Spatial Lag of INMR	Computed
Θ OTMR	Spatial Lag of OTMR	Computed
Θ MHYR	Spatial Lag of MHYR	Computed
Θ GEXR	Spatial Lag of GEXR	Computed
Initial Condition Variables		
EMPt-1	Employment, 1980, 1990	County & City Data Book
INMt-1	In-migration, 1980, 1990	Internal Revenue Service
OTMt-1	Out-migration , 1980, 1990	Internal Revenue Service
MHYt-1	Median Household Income, 1979, 1989	Bureau of Economic Analysis
GEXt-1	Local Public Expenditures per Capita, 19821992	U.S. Bureau of the Census
Regional and Policy Variables		
AREA	Land Area in square miles, 1980, 1990	U.S. Bureau of the Census
POPs	Population , 1980, 1990	U.S. Bureau of the Census
POP2	Population-square, 1980, 1990	U.S. Bureau of the Census
POP5-17	Percent of population between 5 -17 years , 1980, 1990	U.S. Bureau of the Census
POP25-44	Percent of population between 25 -44 years old , 1980, 1990	U.S. Bureau of the Census
FHHF	Percent of Female Householder, Family Householder, 1980, 1990	County & City Data Book
SCRM	Serious crime per 100,000 population, 1980, 1990	County & City Data Book
POPHD	Persons 25 years and over, % high school, 1980, 1990	County & City Data Book
POPCD	Persons 25 years and over, % bachelor's degree or above, 1980, 1990	County & City Data Book
OWHU	Owner-Occupied Housing Unit in percent, 1980, 1990	U.S. Bureau of the Census
MCRH	Median Contract Rent of Specified Renter-Occupied , 1980, 1990	U.S. Bureau of the Census
UNEMP	Unemployment Rate , 1980, 1990	Bureau of Labor Statistics
MANU	Percent employed in manufacturing , 1980, 1990	County & City Data Book
WHRT	Percent employed in wholesale and retail trade , 1980, 1990	County & City Data Book
DFEG	Direct Federal Expenditures and Grants per Capita,1982, 1992	County & City Data Book
PCTAX	Per Capital Local Tax ,1982, 1992	County & City Data Book
PCPTAX	Property Tax per Capita ,1982, 1992	County & City Data Book
PCTD	Total Debt Outstanding per capita ,1982, 1992	County & City Data Book
LTD	Long-Term Debt, Utility , 1982,1992	County & City Data Book
SCIX	Social Capital Index ,1990, 1997	Rupasingha *et al*, 2006
NAIX	Natural Amenities Index 1980, 1990	USDA
HWD	Highway Density , 1980, 1990	US Highway Authority
ESBd	Establishment Density , 1980, 1990	County Business Pattern
EXPTAX	Local General Expenditure/ Personal Income Tax, 1980, 1990	Computed

Table 2a: Descriptive Statistics for Appalachia Counties, 1980-1990.

Variable	Variable Description	Mean	Std Dev	Minimum	Maximum
EMPR	Growth Rate of Employment,1980-1990	0.17738	0.27769	-1.11305	1.30846
INMR	Growth Rate of Gross In-Migration, 1980-1990	-0.09866	0.36722	-3.87267	1.44365
OTMR	Growth Rate of Gross Out-Migration, 1980-1990	-0.13212	0.22534	-1.39099	0.59843
MHYR	Growth Rate of Median Household Income, 1979-1989	0.48556	0.12818	0.042537	0.8413
GEXR	Growth Rate of Local Public Expenditures Per Capita, 1982-1992	0.66384	0.20775	-0.27187	1.49325
Θ EMPR	Spatial Lag of EMPR	0.18525	0.13323	-0.32181	0.62858
Θ INMR	Spatial Lag of INMR	-0.10052	0.18898	-1.33175	0.44524
Θ OTMR	Spatial Lag of OTMR	-0.13074	0.12333	-0.53841	0.19502
Θ MHYR	Spatial Lag of MHYR	0.4864	0.088406	0.22941	0.70964
Θ GEXR	Spatial Lag of GEXR	0.66848	0.093982	0.42664	0.95991
AREA	Land Area in square miles ,1980	6.00594	0.76791	0.83291	7.27219
POPs	Population ,1980	10.28041	0.94001	7.98514	14.18721
POP2	Population-squared, 1980	106.5683	19.78781	63.76253	201.2769
POP5-17	Percent of population between 5 -17 years , 1980	3.08638	0.097505	2.48372	3.30813
POP25-44	Percent of population between 25 -44 years old, 1980	3.26112	0.07749	2.85977	3.62103
FHHF	Percent of Female Householder, Family Householder, 1980	2.19815	0.18039	1.7134	3.07215
SCRM	Serious crime per 100,000 population , 1980	2193.043	1410.51	0	8329
POPHD	Persons 25 years and over, % high school, 1980	3.88069	0.22374	3.22884	4.39174
POPCD	Persons 25 years and over, % bachelor's degree or above, 1980	2.0926	0.37868	1.02985	3.59229
OWHU	Owner-Occupied Housing Unit in percent, 1980	4.32536	0.068858	4.01096	4.45318
MCRH	Median Contract Rent of Specified Renter-Occupied , 1980	4.70784	0.26485	3.89182	5.48894
UNEMP	Unemployment Rate , 1980	2.1016	0.32516	1.03513	3.17018
MANU	Percent employed in manufacturing , 1980	30.19625	12.11241	2.38955	61.54639
WHRT	Percent employed in wholesale and retail Trade, 1980	16.54802	3.31096	6.7223	25.24811
DFEG	Direct Federal Expenditures and Grants per Capita,1982	7.42292	0.41464	6.45363	10.105
PCTAX	Per Capital Local Tax ,1982	5.13622	0.62646	2.958	6.40228
PCPTAX	Property Tax per Capita ,1982	4.80801	0.66627	2.83321	6.39526
PCTD	Total Debt Outstanding per Capita ,1982	618.9139	817.6579	0	8770
LTD	Long-Term Debt, Utility ,1982	4635.421	12347.1	0	134368
SCIX	Social Capital Index ,1980	-0.58184	0.91079	-3.19681	2.03804
NAIX	Natural Amenities Index ,1980	0.14333	1.15867	-3.72	3.55
HWD	Highway Density ,1980	0.67484	0.4084	-0.34252	2.36665
ESBs	Establishment Density ,1980	2.6477	0.32883	0.66964	3.89906
EXPTAX	Local General Expenditure/ Personal Income Tax,1980	1.07349	0.46437	-0.8322	2.24636
EMPt-1	Employment,1980	8.64911	1.2794	5.15906	13.30679
INMt-1	Gross In-Migration,1990	7.1862	0.96288	4.84419	10.33634
OTMt-1	Gross Out-Migration,1980	7.16981	0.95204	4.98361	10.7377
MHYt-1	Median Household Income,1979	9.45834	0.1985	8.80583	10.02447
GEXt-1	Local Public Expenditures per Capita,1982	6.56192	0.28627	5.92693	7.48549

Note: All variables except SCRM, PCTD, LTD, SCIX and NAIX are in log form

Table 2b: Descriptive Statistics for Appalachia Counties, 1990-2000.

Variable	Description	Mean	Std Dev	Minimum	Maximum
EMPR	Growth Rate of Employment, 1990-2000	0.17672	0.24499	-0.69448	1.7868
INMR	Growth Rate of Gross In-Migration, 1990-2000	0.096241	0.24922	-0.92655	1.08588
OTMR	Growth Rate of Gross Out-Migration, 1990-2000	0.096679	0.22048	-1.09537	0.99832
MHYR	Growth Rate of Median Household Income, 1989-1999	0.47743	0.30826	-0.49426	1.39569
GEXR	Growth Rate of Local Public Expenditures Per Capita, 1992-2002	0.61617	0.44636	-0.54832	4.95896
Θ EMPR	Spatial Lag of EMPR	0.17629	0.13013	-0.12982	0.84378
Θ INMR	Spatial Lag of INMR	0.094796	0.22541	-0.45875	0.80957
Θ OTMR	Spatial Lag of OTMR	0.092459	0.15939	-0.33829	0.57753
Θ MHYR	Spatial Lag of MHYR	0.47791	0.16818	0.076696	1.00418
Θ GEXR	Spatial Lag of GEXR	0.61467	0.17942	0.1598	1.83703
AREA	Land Area in square miles ,1990	6.00903	0.74824	1.09861	7.27656
POPs	Population ,1990	10.29714	0.94766	7.87664	14.10553
POP2	Population-squared,1990	106.9271	19.95609	62.04143	198.9659
POP5-17	Percent of population between 5 -17 years ,1990	2.92443	0.12003	2.17475	3.22287
POP25-44	Percent of population between 25 -44 years old,1990	3.37993	0.077483	2.78501	3.74479
FHHF	Percent of Female Householder, Family Householder,1990	2.32185	0.20314	1.81143	3.18787
SCRM	Serious crime per 100,000 population ,1990	2284.809	1561.256	0	8487
POPHD	Persons 25 years and over, % high school,1990	4.10041	0.1706	3.56953	4.4682
POPCD	Persons 25 years and over, % bachelor's degree or above,1990	2.26938	0.40654	1.30833	3.7305
OWHU	Owner-Occupied Housing Unit in percent,1990	4.32524	0.076094	3.86703	4.47278
MCRH	Median Contract Rent of Specified Renter-Occupied ,1990	5.64139	0.20586	4.94164	6.35784
UNEMP	Unemployment Rate ,1990	2.15356	0.34816	1.22378	3.24649
MANU	Percent employed in manufacturing ,1990	26.24019	11.29556	2.2	53.6
WHRT	Percent employed in wholesale and retail Trade,1990	18.82775	3.53195	8.7	27.7
DFEG	Direct Federal Expenditures and Grants per Capita,1992	7.98688	0.3758	6.98286	10.1766
PCTAX	Per Capital Local Tax ,1992	5.91452	0.52985	4.50736	7.42253
PCPTAX	Property Tax per Capita ,1992	5.5236	0.61602	3.91202	7.36265
PCTD	Total Debt Outstanding per Capita ,1992	1180.022	2271.215	0	30332
LTD	Long-Term Debt, Utility ,1992	11728.35	71189.12	0	1368142
SCIX	Social Capital Index ,1990	-0.59298	0.95959	-2.5266	5.64457
NAIX	Natural Amenities Index ,1990	0.14333	1.15867	-3.72	3.55
HWD	Highway Density ,1990	0.69039	0.40412	-0.33914	2.63189
ESBs	Establishment Density ,1990	2.92833	0.3351	1.87398	4.09316
EXPTAX	Local General Expenditure/ Personal Income Tax,1990	0.8429	0.51449	-0.98373	2.60823
EMPt-1	Employment,1990	8.82649	1.25425	5.42054	13.38131
INMt-1	Gross In-Migration,1990	7.08755	1.00192	4.54329	10.51994
OTMt-1	Gross Out-Migration,1990	7.03768	0.97551	4.49981	10.54952
MHYt-1	Median Household Income,1989	9.9439	0.2261	9.05894	10.68093
GEXt-1	Local Public Expenditures per Capita,1992	7.22576	0.27948	6.49224	8.10832

***Note**: All variables except SCRM, PCTD, LTD, SCIX and NAIX are in log form*

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

	EMPR Equation		**INMR Equation**		**OTMR Equation**		**MHYR Equation**		**GEXR Equation**	
VARIABLE	*Coeff.*	*t-stat.*	*Coeff.*	*t-stat.*	*Coeff.*	*t-stat.*	*Coeff.*	*t-stat.*	*Coeff.*	*t-stat.*
CONSTANT	-0.7211	-1.4514	-0.3951	-1.6652	1.9110	7.3054	5.2007	6.7117	1.2586	5.1725
EMPR			1.1016	23.1230	0.5377	19.0894	0.1310	4.5632	-0.0031	-0.1148
INMR	0.0641	4.0017			-0.0264	-2.0152	0.0169	1.4344	-0.0594	-4.9518
OTMR	0.3717	8.6826	-0.5873	-13.8519			0.2131	6.1175	0.0613	2.2006
MHYR	0.2127	5.6273	-0.5129	-8.3058	-0.3917	-11.2243			-0.2373	-7.6835
GEXR	0.2897	6.4475	-0.5322	-8.6811	-0.3497	-9.1948	-0.3711	-10.1317		
Θ EMPR	-0.6500	-8.6300	0.3043	2.4562	0.2703	3.4283	-0.0058	-0.0818	-0.0441	-0.6429
Θ INMR	-0.0411	-0.7687	0.0225	0.3250	0.0010	0.0245	-0.0434	-1.3105	0.0554	1.6872
Θ OTMR	0.4872	4.9039	0.1952	1.4483	0.0469	0.5525	0.0909	1.3352	-0.0792	-1.1835
Θ MHYR	-0.1368	-1.3878	-0.0576	-0.4397	-0.2318	-2.6638	0.2394	3.5123	0.0527	0.9063
Θ GEXR	0.1875	1.8502	0.2020	1.1995	0.2256	2.2746	0.1866	2.4472	0.4216	5.5303
AREA			-0.0369	-1.5766	-0.0041	-0.2604				
POPs			0.5519	20.3534	0.2187	18.4429	-0.1567	-1.0471	0.0098	0.9167
POPd							0.0064	0.8912		
POP5_17									0.1267	2.7955
POP25_44	0.2694	3.8239								
FHHF	-0.0992	-4.1690					-0.0236	-1.0391		
POPHD							0.3128	7.5692		
POPCD	0.1754	7.9801								
OWHU	0.0578	0.5831			-0.0929	-1.6064				
MCRH			0.1141	8.1934						
UNEMP			-0.3036	-9.3346	-0.1679	-8.1801	-0.0026	-0.1692		
MANU	0.0032	5.4736					0.0023	5.1125		
WHRT	0.0181	7.3968					-0.0007	-0.3755		
SCRM									0.0410	0.4946
DFEG									0.0529	3.9894
PCTAX									0.0486	4.6624
PCPTAX	-0.0051	-0.6112								
PCTD									-0.0001	-4.6535
LTD									0.0017	4.8203
SCIX							-0.0099	-1.3853		
NAIX	0.0169	3.0763	0.0192	2.3163	0.0084	1.7953				
HWD	0.1808	6.5349								
ESBd	-0.1162	-4.7651								
EXTAX			0.0768	3.1002	0.0226	1.4816				

EMPt-1	-0.0873	-9.2827								
INMt-1			-0.6774	-23.8148						
OTMt-1					-0.2836	-22.4302				
MHYt-1							-0.5228	-18.9127		
GEXt-1									-0.2771	-13.3590
RHO	0.5713		0.0398		0.3429		0.0006		-0.3976	
SIGV	0.0603		0.0866		0.0396		0.0534		0.1236	
SIG1	0.063		0.0776		0.0465		0.0448		0.1028	
$nR^2 \sim \chi^2_{(58,39,39,56,51)}$ [a]	48.2655	0.8152 [b]	20.5561	0.9937 [b]	29.9805	0.8498 [b]	44.1519	0.8740 [b]	57.2199	0.2553 [b]
Moran I	0.2895	4.5932 [c]	0.061	2.1414 [c]	0.1534	3.1612 [c]	-0.0029	-0.0695 [c]	-0.1176	-3.1981 [c]
Eta (η)	0.0873		0.6774		0.2836		0.5228		0.2771	
PE test	log		log		log		log		log	
n	836		836		836		836		836	

Note: *A coefficient is considered as statistically significant at 10 percent, 5 percent and 1 percent levels, if*

$$1.65 \leq |\text{t-stat.}| \leq 1.98,\ 1.98 < |\text{t-stat.}| \leq 2.58, \text{ and } |\text{t-stat.}| > 2.58$$ *, respectively.*

[a] *58, 39, 39,56, 51 represent the degree of freedoms which are equal to the over-identifying restrictions in the EMPR, INMR, OTMR, MHYR, GEXR equations, respectively.*

[b] *p-values,*

[c] *Z-values for Moran I*