Modeling Migration Effects on Agricultural Lands: A Growth Equilibrium Model

Yohannes G. Hailu and Randall S. Rosenberger

We estimate a system-of-equations model designed to measure the interaction between intertemporal patterns of changes in population, employment, and agricultural land densities. The model is applied to West Virginia for the 1990–1999 period. Consistent with recent findings on migration patterns, the results show that jobs followed people. New jobs were captured by commuters, while agricultural land losses were occurring in the commuters' counties of origin or bedroom communities. However, counties with relatively more profitable and concentrated agricultural enterprises were less susceptible to alternative land use pressure than counties with less productive or fragmented agricultural land. Elasticities indicate population change is elastic, whereas employment and agricultural land density changes are inelastic to factors affecting them. Growth management, when combined with agricultural land retention programs, may be most effective at preserving agricultural land in high growth or potential growth areas.

Key Words: agricultural land, growth equilibrium modeling, land use change, population and employment growth

Urban and rural economic structure in the United States has changed significantly over the past two decades. Previous studies have found that regional growth patterns are in part determined by "rural renaissance" and "urban flight," a shifting economic base, and a change in employment opportunities (Dissart and Deller, 2000; Power, 1996; Lewis, Hunt, and Plantinga, 2002). "Rural renaissance" and "urban flight" may be a result of the interplay between two significant forces—urban growth and externalities associated with urban residence, and amenity benefits of suburban and rural environments.

Negative externalities of urban residences resulting from fiscal and social problems (push factors) create incentives to migrate to areas where these negative externalities are lower (Mieszkowski and Mills, 1993). Other factors, such as population growth, household income, agricultural land rents, and commuting costs, determine sprawl and urban growth at the fringe (Brueckner and Fansler, 1983). Underlying forces of land use change at the urban fringe have become significant, as evidenced by a 40% increase in defined urban land between 1982 and 1997, with 70% of cropland being converted to urban uses (Vesterby and Krupa, 1997).

Agricultural land in the rural environment may provide scenic views, recreational opportunities, and other nonmarket environmental benefits that attract new development (Irwin and Bockstael, 2001; Dissart and Deller, 2000). These rural qualities and endowments (pull factors) affect urban migration decisions, as households are drawn to areas with higher quality-of-life or amenity factors (Dissart and Deller, 2000). Gradual changes in spatial residential preference and decentralization of residential places are followed by decentralization of employment

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growth (Mieszkowski and Mills, 1993). Consequently, suburban places might eventually become centers of economic activity exerting new influences on surrounding suburban and rural land use and creating further incentives for suburban expansion (Isackson and Ecker, 2001).

Complex urban-rural intertemporal economic interactions and growth affect rural agricultural activity in general and agricultural land use in particular. Sprawl and its attendant social infrastructure demand land from existing sectors in the suburban and rural economies. In a competitive land market, the price for land equals the discounted present value of the stream of future rents.[1] Thus, it is expected that if rents from development exceed agricultural rents in the future, the higher rents from development will be capitalized into the current price of agricultural land (Plantinga and Miller, 2001). As development pressure intensifies following the out-migration of population and businesses to suburban areas, more land may be allocated for housing and development purposes because these economic activities might provide a better bid than competing agricultural and other rural economic activities (Isackson and Ecker, 2001).

This study introduces a system-of-equations model that integrates agricultural land use changes in a population and employment growth equilibrium modeling framework. The model has the potential to measure the direct and indirect marginal effects of a variety of factors associated with changes in population, employment, and land uses. If measures of land use policies are included, the model has the potential to measure the effect of these policies in conserving agricultural land and redirecting population and employment growth patterns. An understanding of the responsiveness of population, employment, and agricultural land uses to policies and other factors affecting them will help in the development of effective management strategies.

Growth equilibrium models were developed to explain employment and population changes for a region. These models measure the direct and indirect linkages between population and employment migration patterns and other exogenous determinants of growth. In their early applications, the framework was used to inform the debate regarding whether people follow jobs or jobs follow people (Carlino and Mills, 1987). Beginning with Roback (1982), this modeling framework was used to identify the direct and indirect linkages between population and employment migration and amenity factors (Knapp and Graves, 1989). Roback's (1982) application investigated the linkages between crime rates and urban migration. More recent applications have examined migration linkages with natural amenities including climate and topography (Carlino and Mills, 1987; Clark and Murphy, 1996), wilderness areas (Duffy-Deno, 1998), natural amenities and recreation supply (Deller et al., 2001), and forested public land (Lewis, Hunt, and Plantinga, 2002). We depart from and add to the literature on growth equilibrium models by integrating the agricultural sector into the framework.

System-of-Equations Model

Households are assumed to maximize utility through the income-constrained consumption of a vector of goods and services, location, and nonmarket amenities. Households also are assumed to be mobile over locations and will migrate until utilities are equalized at alternative locations.

Producers are assumed to maximize profit from the production of goods and services. Firms select locations to capture cost and revenue advantages, minimize the cost of transportation, and benefit from agglomeration and regional labor cost differences. Firms enter and leave regions until competitive profits are equalized across regions.

In a general equilibrium framework, population and employment are affected not only by each other, but also by a variety of other factors. In principle, many variables might be simultaneously determined in such a general equilibrium model along with population and employment (Carlino and Mills, 1987). Therefore, the static variables will be expressed as beginning endowments over the assessed time period. This procedure treats the initial conditions as given or exogenous.

Maintaining our behavioral assumptions on economic agents and following Steinnes and Fisher (1974), the simultaneous interaction of equilibrium population and equilibrium employment, and their interaction with agricultural land, may be modeled as follows:

(1) $P\ (\ '\ f_1(E{*}\boldsymbol{\Omega}^P)$,

(2) $E\ (\ '\ f_2(P{*}\boldsymbol{\Omega}^E)$,

(3) $AgL\ (\ '\ f_3(P, E{*}\boldsymbol{\Omega}^{AgL})$,

[1] The argument that land prices equal the present value of future rents is based on the assumption that future benefits from land can be known, or at least can be expected, under competitive markets.

where P, E, and AgL refer to population, employment, and agricultural land, respectively; an asterisk denotes equilibrium levels; and $\mathbf{\Omega}^P$, $\mathbf{\Omega}^E$, and $\mathbf{\Omega}^{AgL}$ refer to vectors of other exogenous variables having a direct or indirect relationship with population, employment, and agricultural land, respectively. Equations (1) and (2) indicate that the equilibrium level of population depends on the level of employment and a vector of exogenous variables which may influence equilibrium population. Similarly, the equilibrium level of employment depends on the level of population and a vector of other exogenous variables which may affect employment. Equation (3) states that the equilibrium level of land in agriculture is influenced by the levels of population and employment, and by other exogenous factors relevant to the extensive margin for land in agriculture.

Population and employment are likely to adjust to their equilibrium values with substantial lags (Mills and Price, 1984). The rate and level of agricultural land conversion in the base year affect the potential for land conversion in the current year; or conversely, equilibrium levels of agricultural land adjust to previous-period conversion patterns. Distributed lag adjustment equations therefore may be introduced as:

$$(4)\quad P_t = P_{t-1} + \lambda_P(P^* - P_{t-1}),$$

$$(5)\quad E_t = E_{t-1} + \lambda_E(E^* - E_{t-1}),$$

$$(6)\quad AgL_t = AgL_{t-1} + \lambda_{AgL}(AgL^* - AgL_{t-1}).$$

Rearranging terms, movements toward equilibrium conditions can be expressed as:

$$(7)\quad \Delta P = P_t - P_{t-1} = \lambda_P(P^* - P_{t-1}),$$

$$(8)\quad \Delta E = E_t - E_{t-1} = \lambda_E(E^* - E_{t-1}),$$

$$(9)\quad \Delta AgL = AgL_t - AgL_{t-1} = \lambda_{AgL}(AgL^* - AgL_{t-1}),$$

where λ_P, λ_E, and λ_{AgL} are speed-of-adjustment coefficients to the equilibrium levels of population, employment, and agricultural land, respectively, and where $0 \le \lambda_P, \lambda_E, \lambda_{AgL} \le 1$; P_t, E_t, and AgL_t are end-of-period levels, and P_{t-1}, E_{t-1}, and AgL_{t-1} are initial-period levels of population, employment, and agricultural land, respectively; and ΔP, ΔE, and ΔAgL are respective changes in population, employment, and agricultural land.

With substitution and rearranging of terms, a linearized expression of the model is written as:

$$(10)\quad \Delta P = \beta_{0P} + \beta_{1P}P_{t-1} + \beta_{2P}\Delta E + \sum \delta_{jP}\mathbf{\Omega}^P,$$

$$(11)\quad \Delta E = \beta_{0E} + \beta_{1E}E_{t-1} + \beta_{2E}\Delta P + \sum \delta_{jE}\mathbf{\Omega}^E,$$

$$(12)\quad \Delta AgL = \beta_{0AgL} + \beta_{1AgL}AgL_{t-1} + \beta_{2AgL}\Delta P + \beta_{3AgL}\Delta E + \sum \delta_{jAgL}\mathbf{\Omega}^{AgL}.$$

Equations (10), (11), and (12) indicate that population and employment changes depend on their own initial levels, and the respective changes in employment and population, as well as a vector of exogenous factors. The change in agricultural land is affected by its initial level, changes in employment and population, and by a vector of other exogenous variables influencing agricultural land changes. Those factors that directly affect changes in population or employment are indirectly captured in the agricultural land change equation through changes in population and employment. Thus, the simultaneous interaction of employment and population and their direct and indirect effects on agricultural land conversion can be identified.

Exogenous Factors

Exogenous factors affecting household migration decisions ($\mathbf{\Omega}^P$) can be classified as *fiscal*, *local*, and *amenity* factors (Duffy-Deno, 1998). Fiscal factors are associated with public-sector costs of moving to a new region and are typically concerned with tax rates and systems. However, overall utility of an area may also depend on how tax revenue is spent. People may be willing to incur higher tax burdens if the funds are spent on public goods such as transportation (roads), safety (fire and police), or education. Local factors may affect household migration decisions through a sense of community, transportation infrastructure, location, health care, and other local characteristics of places. Amenity factors may also directly affect migration decisions and may include climate, open space, and recreational opportunities (Dissart and Deller, 2000).

Exogenous factors affecting business location decisions ($\mathbf{\Omega}^E$) may include *fiscal*, *business and local*, *amenity*, and *other exogenous factors*. Fiscal factors are associated with public-sector costs and benefits of locating to a new region and may include tax burdens, or these burdens may be mitigated through their expenditure on public services provision. Business factors affecting firm location may include geographic location and labor market characteristics. These factors are associated with workforce quality and access to markets. Business owners and managers may also benefit through amenity factors associated with certain locations, or the nature of their business is dependent upon access to these amenities (e.g., hunting outfitters). Other exogenous factors associated with firm location decisions may include exogenous injections into the local economy through multiplier effects and the share of employment in different economic sectors.

Exogenous factors associated with changes in agricultural land ($\mathbf{\Omega}^{AgL}$) may include *fiscal*, *business and local*, and *land use policy*. Fiscal factors for agricultural land conversion measure the economic stability of agriculture in a region. Farmers are more likely to remain in agriculture the higher their net returns from farming. Similarly, costs (such as farmers' tax burdens) directly affect business cash flows, and indirectly decisions to sell land. Business and local factors include market access, agglomeration effects in agriculture, and the market value of land. Policy factors are exogenous forces that may directly (conservation easements, zoning) or indirectly (an increase in agricultural net returns through subsidies) affect land conversion rates.

An Application to West Virginia

We fit the system-of-equations model to county-level data for West Virginia. The analysis period is 1990 to 1999. During this period, West Virginia experienced an overall increase in population of about 0.4%, with certain counties having population gains while others had population losses. From 1992 to 1997, the total number of jobs in the state increased by approximately 10% (U.S. Department of Commerce/Bureau of Economic Analysis, REIS database), while urban land increased by 36%. Of this 36% increase in urban land, 63% was due to the conversion of forested land, 16% was from cropland, and 14% from pastureland (USDA, *Agricultural Statistics*).

Table 1 defines the variables used in this application. Population, employment, and agricultural land are measured as densities per square mile. The endogenous variables (ΔP, ΔE, and ΔAgL) are measured as changes in population density, employment density, and agricultural land density per square mile per county from 1990 to 1999, respectively. Population density changes ranged from a maximum loss of 29 people per square mile to a maximum gain of 40 people per square mile. The average change in population was 0.43 people per square mile, which relates to a 0.4% increase in total population for the state during this period.

Employment density changes ranged from a maximum loss of 23 jobs per square mile to a maximum gain of 33 jobs. The average change in employment during this period was 4.39 jobs per square mile, which relates to an overall increase in employment of 10% for this period.

Agricultural land density changes ranged from a maximum loss of 21 acres per square mile to a maximum gain of 45 acres per square mile. The average change in agricultural land density was an increase of 9.76 acres per square mile. The initial conditions, or endowments, in 1990 for population, employment, and agricultural land densities ($DPOP_{90}$, $DEMP_{90}$, and DAG_{90}) measured per square mile were 94 people, 43 jobs, and 144 acres of agricultural land, respectively (table 1).

Population Equation

Population growth from 1990 to 1999 depends on the initial population density in 1990 and a number of exogenous factors hypothesized to affect household utility and decisions to migrate. We hypothesize that households will migrate to areas of lower per capita taxes ($PCTAX_{90}$). However, depending on how the revenue collected is spent (e.g., public-sector services such as police and firefighting), the negative effect of per capita taxes may be mitigated.

Local and business factors are captured by several variables identifying local characteristics relevant to each of the actors in the models (Dissart and Deller, 2000). Households' decisions to migrate may be influenced by accessibility to places of employment or recreational opportunities. Interstate highway density in 1999 ($HWYDEN_{99}$), adjacency to metropolitan counties ($METADJ_{93}$), and distance to nearest major metropolitan area ($NEARDIST$) are used to capture accessibility and transportation infrastructure. Additional measures of commuting patterns are captured by the proportion of employed residents whose jobs are outside their county of residence ($POUTWORK_{90}$), and the proportion of jobs in a county held by people residing outside of the county ($PINMIGRT_{90}$). Median housing value ($MEDHVA_{90}$), owner occupancy rates for single-family housing structures ($OWNOCC_{90}$), and the unemployment rate ($UNEMRT_{90}$) are used to measure an overall sense of community (Duffy-Deno, 1998).

Many variables previously used to measure amenity differences are not relevant to our application given they do not vary significantly across West Virginia, such as climate and topography.

Table 1. Definition and Summary of Variables, West Virginia, 1990–1999 (N = 55)

Variable	Definition	Source[a]	Mean	Standard Deviation
Endogenous Variables:				
ΔP	Change in population density ($DPOP_{99} - DPOP_{90}$)	A	0.43	9.72
ΔE	Change in employment density ($DEMP_{99} - DEMP_{90}$)	A	4.39	9.03
ΔAgL	Change in agricultural land density ($DAG_{99} - DAG_{90}$)	B	9.76	15.64
Initial Conditions:				
$DPOP_{90}$	Population density in 1990	A	94.40	102.89
$DEMP_{90}$	Employment density in 1990	A	42.66	59.92
DAG_{90}	Agricultural land density in 1990	B	143.88	84.04
Fiscal Factors:				
$PCTAX_{90}$	Per capita local taxes in 1990	C	315.11	126.39
$AGSLAC_{90}$	Agricultural sales per acre in 1990	C	83.22	70.24
Local and Business Factors:				
$HWYDEN_{99}$	Interstate highway density in 1999	D	0.02	0.04
$MEDHVA_{90}$	Median housing value in 1990 ($000s)	C	44.61	10.72
$OWNOCC_{90}$	Owner occupancy rate for housing in 1990	C	0.77	0.04
$UNEMRT_{90}$	Unemployment rate in 1990	C	0.11	0.04
$METADJ_{93}$	Non-metro counties with # 20K adjacent to metro counties in 1993	E	0.25	0.44
NEARDIST[b]	Distance to nearest major metropolitan area (miles)	—	62.41	25.44
$PCROP_{90}$	Proportion of agricultural land in cropland in 1990	B	0.40	0.11
$PPAST_{90}$	Proportion of agricultural land in pasture in 1990	B	0.53	0.14
$POUTWORK_{90}$	Proportion of employed residents working outside county of residence in 1990	C	0.33	0.15
$PINMIGRT_{90}$	Proportion of total jobs in a county held by people residing outside county in 1990	C	0.18	0.08
Amenity Factors:				
$PFEDL_{92}$	Proportion of land base in federal ownership in 1992	F	0.05	0.10
$PCOUNTY_{92}$	Proportion of land base in county ownership in 1992	F	0.01	0.01
$PWATERAC_{92}$	Proportion of land base covered by water in 1992	F	0.01	0.01
$PFORESTL_{92}$	Proportion of land base forested in 1992	F	0.67	0.15
Other Exogenous Factors:				
$PAGEMP_{90}$	Proportion of total employment in agriculture in 1990	A	0.06	0.06
$PMIEMP_{90}$	Proportion of total employment in mining in 1990	A	0.08	0.08
$PCNEMP_{90}$	Proportion of total employment in construction in 1990	A	0.06	0.02
$PSVEMP_{90}$	Proportion of total employment in services in 1990	A	0.21	0.05

[a] *Sources:* A = U.S. Department of Commerce, Bureau of Economic Analysis (REIS database); B = USDA, *Agricultural Statistics*; C = U.S. Department of Commerce, Bureau of the Census, *1990 Census of the Population*; D = U.S. Department of Transportation; E = USDA, Economic Research Service; F = USDA, Natural Resources Conservation Service, *National Resources Inventory*.

[a] Nearest major metropolitan areas are defined by linear miles from Washington, DC, Charleston, WV, or Pittsburgh, PA.

We use several land ownership variables to proxy natural amenities, including a measure of agricultural land density (DAG_{90}), the proportion of each county's base that is federally managed ($PFEDL_{92}$), forested ($PFORESTL_{92}$), or in water resources such as lakes and rivers ($PWATERAC_{92}$).

Employment Equation

Employment growth from 1990 to 1999 depends on the initial employment density in 1990 and a number of exogenous factors important to firms' decisions to locate in an area (Dissart and Deller, 2000). Per capita local tax ($PCTAX_{90}$) affects firm location decisions analogously with residential location decisions; firms prefer locations with lower tax burdens, all else equal. Firm location decisions may be affected by access to markets and workforce availability and quality (Dissart and Deller, 2000). We measure access by interstate highway density ($HWYDEN_{99}$), adjacency to metropolitan areas ($METADJ_{93}$), and distance to nearest major metropolitan area (*NEARDIST*). Workforce availability is measured by the unemployment rate ($UNEMRT_{90}$).

The decomposition of employment into economic sectors measures the role of each sector in West Virginia. Dependence on an economic sector is measured as its proportion of total jobs in each county. Resource-dependent sectors such as agriculture ($PAGEMP_{90}$) or mining ($PMIEMP_{90}$) have limited mobility, as they require location-specific inputs (land, minerals) in their production processes. Mining is a significant employer in certain counties, which also exhibit declining populations and employment opportunities. The construction sector ($PCNEMP_{90}$) typically expands and contracts based on demand for its products. The services sector ($PSVEMP_{90}$) is the fastest growing and is the dominant sector for most counties in terms of number of jobs.

Agricultural Land Conversion Equation

Although farmers are not considered to be geographically mobile due to their dependence on spatially located resources (land), farmers' decisions to sell their land to developers may be influenced by their earnings from agricultural production on the land (Lynch and Carpenter, 2003). Therefore, higher sales per acre ($AGSLAC_{90}$) may result in greater resistance to external demands for their land. The proportion of total employment in the agricultural sector ($PAGEMP_{90}$) is also an indicator of agriculture's role in local economies. The density of agricultural lands in the initial period (DAG_{90}) is a measure of critical mass of agricultural activity.

To capture the effect of development access to agricultural land, and agriculture to markets, spatial indicators of accessibility are measured as highway density ($HWYDEN_{99}$), a dummy variable separating urban adjacent counties from nonurban adjacent counties ($METADJ_{93}$), and distance from urbanized locations (*NEARDIST*). Community characteristics may have an impact on suburban agricultural lands as commuters demand land for development purposes in the place of their residence while they work at a different location. To capture this effect, $PINMIGRT_{90}$ measures the proportion of jobs held in a county by residents who live outside the county. $POUTWORK_{90}$ measures the proportion of employed residents of a county whose jobs are in a county other than their county of residence.

Model Results

The model's estimated coefficients, *t*-statistics, and elasticities are reported in table 2. A Hausman's specification test for simultaneity between population density change (ΔP) and employment density change (ΔE) showed significant simultaneity. However, there is no significant simultaneity between changes in employment (ΔE) and population (ΔP) with changes in agricultural land density (ΔAgL). Therefore, the first two equations in the model were fit using a two-stage least squares estimator. The last equation in the model is estimated using Ordinary Least Squares Estimator, as the variables on the right-hand side are exogenous to the agricultural land equation. Consequently, our system of equations has a simultaneous component (population and employment equations) and a recursive component (population-employment equations and agricultural land equation).

As observed from the adjusted R^2 values in table 2, the model explains 71%, 66%, and 19% of the variation in population density change (ΔP), employment density change (ΔE), and agricultural land density change (ΔAgL), respectively. Variables that are specified in each equation are statistically significant in only one equation, with the exception of the highway density variable ($HWYDEN_{99}$). There is no single, universally applicable factor which could be used to explain population, employment, and agricultural land changes. However, factors significantly associated with changes in population density (ΔP) indirectly enter as factors associated with employment density change (ΔE), given that ΔP is a determining factor for ΔE.

Interpretation of the signs on the coefficients are straightforward; a negative sign indicates lower, or even negative changes, while a positive coefficient indicates higher growth. Changes in population (ΔP) were not significantly determined by changes in employment density (ΔE) in our study. However, employment density change (ΔE) was significantly determined by changes in population density (ΔP). Based on the estimated coefficients, a 4% increase in population density resulted in a 1% increase in employment density, all else equal. This result supports previous evidence that population growth is a catalyst for job creation more so than job creation for population growth (Deller et al., 2001; Kusmin, Redman, and Sears, 1996; Lewis, Hunt, and Plantinga, 2002).

From table 2, the population density change equation has six coefficient estimates that are statistically

Table 2. Empirical Results for System-of-Equations Model, West Virginia, 1990–1999 ($N = 55$)

	Population Equation (ΔP)			Employment Equation (ΔE)			Agricultural Land Equation (ΔAgL)		
Variable	Coeffic.	*t*-Statis.	Elasticity	Coeffic.	*t*-Statis.	Elasticity	Coeffic.	*t*-Statis.	Elasticity
Constant	!17.66	(!0.72)	—	!10.03	(!0.94)	—	!1.56	(!0.13)	—
Endogenous Variables:									
ΔP	—	—	—	0.26*	(2.38)	5.70	!0.14	(!0.70)	!0.01
ΔE	0.33	(1.13)	3.44	—	—	—	0.41	(1.26)	0.18
Initial Conditions:									
$DPOP_{90}$	!0.08*	(!4.03)	!17.28	—	—	—	—	—	—
$DEMP_{90}$	—	—	—	0.01	(0.12)	0.07	—	—	—
DAG_{90}	!0.03	(!1.35)	!10.47	0.01	(0.13)	0.06	0.08*	(2.01)	1.24
Fiscal Factors:									
$PCTAX_{90}$	!0.01	(!0.28)	!1.48	!0.01	(!0.92)	!0.43	—	—	—
$AGSLAC_{90}$	—	—	—	—	—	—	!0.08*	(!3.04)	!0.67
Local and Business Factors:									
$HWYDEN_{99}$	!5.80	(!0.10)	!0.30	157.50*	(2.86)	0.79	!174.70*	(!1.85)	!0.39
$MEDHVA_{90}$	0.62*	(4.64)	64.72	—	—	—	—	—	—
$OWNOCC_{90}$	33.94*	(1.69)	61.18	—	—	—	—	—	—
$UNEMRT_{90}$	55.48*	(2.10)	14.46	!20.59	(!0.86)	!0.52	—	—	—
$METADJ_{93}$	!1.98	(!1.22)	!1.16	!1.74	(!1.42)	!0.10	13.35*	(3.06)	0.34
$NEARDIST^{b}$	!0.04	(!0.80)	!5.27	0.01	(0.16)	0.07	0.12	(1.27)	0.79
$PCROP_{90}$	—	—	—	—	—	—	6.83	(0.45)	0.28
$PPAST_{90}$	—	—	—	—	—	—	1.38	(0.13)	0.07
$POUTWORK_{90}$	8.04	(1.40)	6.23	!0.87	(!0.23)	!0.06	!23.74*	(!1.86)	!0.80
$PINMIGRT_{90}$	!8.58	(!0.88)	!3.62	23.11*	(2.40)	0.95	11.53	(0.45)	0.21
Amenity Factors:									
$PFEDL_{92}$	!39.12*	(!2.47)	!4.56	—	—	—	—	—	—
$PCOUNTY_{92}$	—	—	—	154.03*	(2.19)	0.07	—	—	—
$PWATERAC_{92}$	!92.28	(!1.20)	!2.95	—	—	—	—	—	—
$PFORESTL_{92}$	!38.40*	(!2.50)	!60.70	—	—	—	—	—	—
Other Exogenous Factors:									
$PAGEMP_{90}$	—	—	—	0.40	(0.03)	0.01	!12.97	(!0.20)	!0.08
$PMIEMP_{90}$	—	—	—	7.86	(0.76)	0.14	—	—	—
$PCNEMP_{90}$	—	—	—	25.81	(1.01)	0.33	—	—	—
$PSVEMP_{90}$	—	—	—	38.39*	(1.72)	1.83	—	—	—
Adjusted R^2		0.71			0.66			0.19	

Notes: An asterisk (*) denotes statistical significance at least at the 0.10 level. The population (ΔP) and employment (ΔE) equations are estimated using a two-stage least squares procedure; the agricultural land (ΔAgL) equation is estimated independently using ordinary least squares. All models are corrected for heteroskedasticity using White's HCCM routine. Elasticities are calculated at sample means.

different than zero at the 10% level or higher, including one initial condition factor ($DPOP_{90}$), three business and local factors ($MEDHVA_{90}$, $OWNOCC_{90}$, and $UNEMRT_{90}$), and two amenity factors ($PFEDL_{92}$ and $PFORESTL_{92}$). Higher population densities ($DPOP_{90}$) entering into the study period were associated with greater population losses over the study period, all else equal. The population density elasticity shows a 1% increase in population density results in more than a 17% reduction in population growth, all else equal. This finding confirms Deller et al.'s (2001) conclusion that areas with higher population densities have lower growth, reinforcing the argument of a rural renaissance.

Counties with higher median housing values ($MEDHVA_{90}$), higher owner occupancy rates for single-family homes ($OWNOCC_{90}$), and higher unemployment rates ($UNEMRT_{90}$) had population increases, all else equal. Median housing values were expected to be negatively associated with household migration patterns; people would choose areas where housing costs are lower. However, this variable may be measuring general trends occurring as we enter the period of analysis. Higher median housing values may be associated with areas of high growth with increased demands for housing and subsequently higher housing prices. Housing value elasticity shows a 1% increase in median housing value is associated with a 65% increase in population growth.

High owner occupancy rates ($OWNOCC_{90}$) reflect a stronger sense of community (Duffy-Deno, 1998). A 1% increase in owner occupancy rates results in a 61% increase in population growth. Households prefer communities that are stable. Counties with higher unemployment rates ($UNEMRT_{90}$) at the beginning of the period experienced higher population growth than counties with lower unemployment rates. A 1% increase in the unemployment rate results in a 14% increase in population growth. This result may be influenced by county residents finding employment in neighboring counties, although our measure of residents working outside their county ($POUTWORK_{90}$) was not statistically significant in the equation.

The two statistically significant amenity factors in the population equation ($PFEDL_{92}$ and $PFORESTL_{92}$) are negatively associated with population change. Although empirical evidence suggests amenity factors are significant determinants of population growth (Dissart and Deller, 2000; Deller et al., 2001), the opposite was found for West Virginia over the 1990–1999 study period. There are several plausible explanations for this unexpected result.[2] First, the measures of amenity factors may be insufficient. Other factors may be causing certain counties to remain highly rural and undeveloped, resulting in an omitted variable problem responsible for biasing the results for the amenity factors. Second, counties with relatively high proportions of their land base in forests or federal ownership may be located in counties with little growth potential due to other factors such as low highway densities and distance from metropolitan areas. This second explanation is strengthened given the fact that highway density ($HWYDEN_{99}$), and distance from metropolitan areas ($NEARDIST$ and $METADJ_{93}$) are not significant determinants of population change.

[2] We thank an anonymous reviewer for providing plausible explanations for our findings regarding the amenity factors as we have measured them.

The employment density change equation has five factor coefficient estimates which are statistically different than zero at the 10% level or higher, including the endogenously determined population density change (ΔP), two business and local factors ($HWYDEN_{99}$ and $PINMIGRT_{90}$), one amenity factor ($PCOUNTY_{92}$), and one other exogenous factor ($PSVEMP_{90}$). Population density change (ΔP) is a significant and positive indicator of employment growth. This result confirms previous findings that jobs follow people in migration patterns for West Virginia during the analysis period.

Interstate highway density ($HWYDEN_{99}$) is positively associated with changes in employment densities, as expected. Access is a significant factor in generating employment (Carlino and Mills, 1987). Thus, counties with a greater access via the interstate highway system have a greater potential to generate employment growth through a comparative advantage of lower transportation costs, all else equal. The elasticity measure shows a 10% increase in interstate highway density results in an 8% increase in employment growth. The proportion of jobs in a county held by nonresidents ($PINMIGRT_{90}$) is positively associated with employment density changes, suggesting people outside the county are supplying labor for newly created jobs. The elasticity measure for in-commuters is nearly unity; a 10% increase in nonresidents holding jobs results in a 10% increase in employment density.

County governments that own a larger proportion of their land base ($PCOUNTY_{92}$) had larger increases in employment densities than county governments with little or no land ownership. Land ownership by counties may be an asset for attracting new businesses or retaining and expanding existing businesses. Counties with larger proportions of total jobs in the services sector ($PSVEMP_{90}$) are associated with higher employment changes. A 10% increase in jobs in the services sector generates an 18% increase in employment density. The services sector is the fastest growing sector in the rural economy (Kusmin, Redman, and Sears, 1996) and is relatively more mobile than other economic sectors (Rasker and Glick, 1994).

The agricultural land density change equation yields five factor coefficient estimates that are statistically different than zero at the 10% level or higher, including one initial condition factor (DAG_{90}), one fiscal factor ($AGSLAC_{90}$), and three business and local factors ($HWYDEN_{99}$, $METADJ_{93}$, and $POUTWORK_{90}$). In this application, neither population density change (ΔP) nor employment density change (ΔE) is statistically significant in the model. This result is troubling since a primary objective of the model was to measure the marginal contributions of these factors in land use change.

Higher agricultural land endowments (DAG_{90}) were associated with an expanding agricultural land base, all else equal. The elasticity for agricultural land shows a 10% increase in agricultural land density in the initial period resulted in a 12% increase in agricultural land density over the study period. Counties having a higher initial agricultural land density or concentration of farming activity increased agricultural lands or at least mitigated agricultural land losses. Conversely, counties with fragmented farmlands or with lower agricultural land density face greater losses of farmland. This finding is consistent with previous studies that concluded counties with a greater quantity of productive farmland can better sustain a viable farm sector and can remain competitive; i.e., farmland losses are in part a function of the number of productive farmland acres (Lynch and Carpenter, 2003).

Higher agricultural sales per acre ($AGSLAC_{90}$) were associated with decreases in agricultural land densities, all else equal. The response of agricultural land growth to sales per acre is inelastic and negative; a 10% increase in agricultural sales per acre in the initial period resulted in a 7% decrease in changes in agricultural land density. Agricultural sales per acre are a measure of the competitiveness of the rural farm sector. In the case of West Virginia, due to the physical geography of the state, most productive agricultural lands are concentrated in the eastern region of the state where there is fertile land and greater market access. However, the Eastern Panhandle portion of this region is also a fast growth area in the state given its proximity to Washington, DC. These competing forces are supported by other results of the model. Higher interstate highway densities ($HWYDEN_{90}$) and higher proportions of residents employed in other counties ($POUTWORK_{90}$) are both associated with reduced changes in agricultural land (with elasticity measures of !0.4 and !0.8, respectively). In contrast, low population rural counties adjacent to metropolitan counties ($METADJ_{93}$) experienced increases in agricultural land over the assessment period.

We investigated this conflicting information further by looking at individual counties. Agricultural land densities increased in those counties with higher densities at the beginning of the period. Higher agricultural sales per acre were associated with lower, but still positive changes in agricultural land. Highway density and expanding bedroom communities were associated with losses in agricultural land. The adjacency to a metropolitan county effect is not relevant to those counties near Washington, DC, given their populations are greater than 20,000. Therefore, the effects of access to versus proximity of markets are not transparent in the estimated parameters. A better measure of access to versus proximity of markets may be necessary; however, our introduction of interaction terms for access and proximity were not significant in the model.

Conclusions

A system-of-equations model was introduced that has the potential to identify and measure the direct marginal effects of various factors associated with population, employment, and land use change. Indirect marginal effects of factors associated with land use change may be measured through the direct effects of population and employment change on land use change. The system-of-equations model is an extension of the growth equilibrium modeling framework developed to measure the simultaneous relationship of population and employment change. We integrated an agricultural land conversion equation into the system as a recursive component. Specification of the equations in the simultaneous component explained a significant proportion of the variation in the dependent variable for each equation. However, the land use change equation did not perform nearly as well, including a lack of significance for both population and employment density changes. We nonetheless remain optimistic regarding future uses and extensions of the model.

Agricultural land as an amenity factor was not found to be a significant determinant of population and employment migration patterns (Dissart and Deller, 2000). However, a significant relationship was found between the growth of bedroom communities and losses of agricultural land. Residential locations may be influenced by the rural amenities associated with agricultural communities, but the actual location of residences also depends upon land availability and location to transportation corridors and markets.

The majority of the elasticity measures for agricultural land changes were inelastic. Land is a fixed input in the agricultural production process and does not flow easily into and out of agriculture. Population elasticities, however, were primarily elastic, illustrating the greater reaction of population to policy stimulants than agriculture. Population is mobile and can migrate in response to changing economic and social conditions much more readily than agriculture, which is tied to an immobile resource—land.

Our results support the argument of Mieszkowski and Mills (1993): Decentralization of employment growth follows decentralization of residential locations. Those factors that were significant in explaining employment changes were inelastic. Most firms are not highly mobile due to their dependence upon investments in capital and land, and workforce availability and access to markets or transportation corridors. The services sector is the primary exception, as evidenced by the positive and elastic measures of services sector employment on overall employment changes (Rasker and Glick, 1994).

Counties in which the largest proportion of residents held jobs outside their home county (also known as "bedroom communities") experienced the greatest losses of agricultural land. In addition, agricultural land density change was most responsive to increases in bedroom community growth, as indicated by elasticity measures. If this result is coupled with the finding that population was most responsive (elastic) to those factors affecting it, then policies targeting factors associated with population growth and housing development may be more effective in preserving agricultural land than policies targeting agricultural enterprises directly.

The model should be extended to include agricultural land retention policies and growth management policies in order to measure their relative, marginal effects on land use changes. None of the traditional land conservation tools were available in West Virginia during the 1990–1999 study period. Therefore, an extension of the model to another region having direct agricultural land conservation tools would be an appropriate test of the model. However, the results of our model do reveal the expected marginal effect of policies that could indirectly conserve agricultural land, including policies designed to increase agricultural sales, locate highway corridors, and influence choice of residential location relative to employment opportunities.

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