2007

Agricultural Land Development in the Northeast United States: A Spatial Simultaneous Growth Equilibrium Model

Yohannes G. Hailu
Michigan State University

Cheryl Brown

Agricultural Land Development in the Northeast United States: A Spatial Simultaneous Growth Equilibrium Model

by

Yohannes G. Hailu and Cheryl Brown

REAEARCH PAPER 2007-2

Abstract: This study introduces a spatial simultaneous growth model to examine the impact of regional growth on agricultural land development. County level data on growth factors, land values, farmland density and a set of exogenous variables are used from 12 Northeast states. Results indicate that regional growth, accessibility, and growth in neighboring counties may negatively impact agricultural land density. Farmland protection policies did not have a significant impact in reducing agricultural land development. Based on these results, cross-county and cross-state land use policy coordination may provide better land management outcomes than a county-level focus that disregards growth and land development interdependences.

Yohannes G. Hailu is Visiting Assistant Professor and Research Coordinator, Land Policy Institute, Michigan State University. Cheryl Brown is Faculty Research Associate, Regional Research Institute and Assistant Professor, Division of Resource Management, West Virginia University.

Introduction

Development of effective land use policies requires understanding the forces that shape regional land use change. Conversion of farmland to urban or suburban uses may have both positive and negative impacts. Suburban places may offer a lifestyle characterized as "high quality" (Brown et al. 1997). Rural areas may provide a quality environment and scenic vistas as well as outdoor recreation opportunities. Development may also bring increased opportunities to farmers in terms of off-farm employment and increased demand for local agricultural products along with higher tax income for local government. Development, however, may bring negative externalities. The direct effect of the loss of farmland can be measured in terms of output reduction and income losses. Indirect impacts may include regulatory restrictions on farming practices, technological impacts, and speculative influences. Ultimately, the critical mass of farming needed to sustain the local farming economy may collapse (Daniels and Nelson 1986; Daniels 1986; Lapping and Fitzsimmons 1982; Lynch and Carpenter 2003).

Another challenge arises from positive externalities of agricultural land that may not be captured in the market value for land. Recently, attention has focused on preserving local benefits from farmland such as open space, environmental quality, and impediments to urban sprawl. Many of these benefits have public characteristics and, as a consequence, will tend to be undersupplied by private producers (Lopez, Shah and Altobello 1994; Plantinga and Miller 2001). In addition, there is value attached to open space, green surroundings, and the peace and serenity some associate with farmland (Bowker and Didychuk 1994; Kline and Wichelns 1996; Ready, Berger and Blomquist 1997; Rosenberger and Loomis 1999). The problem for surrounding communities is that the cash-driven marketplace often does not recognize these amenities (Gardner 1977). As a result, many states have initiated some type of land use policy tools to manage the loss of agricultural land and its associated private and public benefits (Nickerson and Hellerstein 2003).

Several studies have modeled the interaction between growth and changes in land use between urban and agricultural uses (Brueckner and Fansler 1983; Mieszkowski and Mills 1993). In general, urban "push factors" and rural and suburban "pull factors" determine the spatial patterns of development and hence agricultural land use change. The urban "push factors" are negative amenities associated with urban life that motivate suburban migration. Fiscal and social problems associated with central cities: high taxes, low quality public schools and other government services, crime, congestion and low environmental quality are expected to lead residents to migrate to suburban places (Mieszkowski and Mills 1993). Following location equilibrium theory, rising per capita income is also associated with growth of communities if it leads to shifts in the demand for location-specific amenities. Since changes in consumption of these amenities can only be possible through relocation (Knapp and Graves 1989), in the long-run, these changing demands may lead to migration to more desirable locations (Graves 1983). Reinforcing the urban flight (sprawl) process, the rural environment, including agricultural land, provides scenic views, recreational opportunities, and other non-market environmental benefits that attract new development (Irwin and Bockstael 2001; Bowker and Didychuk 1994; Kline and Wichelns 1996; Ready, Berger, and Blomquist 1997; Rosenberger and Loomis 1999; 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). Deller et al. (2001) argue that in addition to local characteristics like taxes and income, a significant relationship between amenities, quality of life, and local economic performance exists. Similarly, Gottlieb (1994), English et al. (2000), Roback (1988), and Henry et al. (1999) indicate that the inclusion of amenity factors in explaining regional growth differences appears powerful.

The sources of suburban and rural growth that determine inter-temporal land use change are numerous and may well extend to factors other than the ones already discussed. Aldrich and Kusmin (1997), for instance, briefly discussed determinants of suburban and rural growth to include variables such as taxation, public spending, the unemployment rate, urbanization, minority population concentration, and local fire protection rates; Bell and Irwin (2002) mention spatial factors like proximity to employment and other activities, natural features, surrounding land use patterns, and land use policies that may affect the pattern of land use change. For the purpose of modeling regional agricultural land use change, the major sources of development of suburban and rural land may be aggregated into forces of population growth, household formation, income growth (Heimlich and Anderson 2001), and employment growth.

This study analyzes the relationships between changes in regional growth and agricultural land development using a spatial simultaneous growth equilibrium model that captures the interactions among growth patterns, income changes, land price differentials, land use policies, and changes in agricultural land density, taking into account the impact of neighboring counties.

Empirical Model

To capture the impact of inter-temporal employment density, population density, income, and agricultural land value changes on farmland stocks, a growth equilibrium model is applied. Growth equilibrium models were initially developed to simultaneously explain growth in employment and population. These models have been used to examine relationships among population and employment changes, migration, and the demand for natural amenities. The empirical model is developed following a set of basic assumptions. It is assumed that mobile consumers maximize utility by consuming a vector of goods and services as well as location and non-market amenities. Households will migrate until marginal utilities are equalized across locations. Households are also assumed to be drawn to regions with higher per capita income growth and employment opportunities. Producers are assumed to maximize profit from the production of goods and services. Firms select locations to capture locational cost and revenue advantages, minimize the cost of transportation, benefit from agglomeration and regional labor cost savings as well as labor quality. Firms enter and leave regions until competitive profits are equalized across regions. It is also assumed that firms and households adjust to disequilibrium over time. In a general equilibrium framework, population, employment, and income are affected not only by each other, but also by a variety of other variables. In principle, many such variables might be simultaneously determined along with population, employment (Carlino and Mills 1987) and income. Agricultural land values and agricultural land stock changes are also assumed to adjust with lags.

Population, employment, income, land values, and agricultural land development may have significant spatial dependence. The existence of spatial autocorrelation was tested by estimating Moran's I statistics for the endogenous variables in this simultaneous system. Results reported in table 1 indicate that a spatial model should be used.

Following the stated assumptions, a simultaneous relationship between agricultural land development and employment growth, population growth, per capita income, farmland values, the stock of agricultural land at a particular time, and the spatial lags of these variables can be specified as:

(1) $$P^* = f_P(E^*, Y^*, V^*, WP^*, WE^*, WY^*, WV^* \mid \Omega^P),$$

(2) $E^* = f_E(P^*, Y^*, V^*, WE^*, WP^*, WY^*, WV^* \mid \Omega^E)$,

(3) $Y^* = f_Y(P^*, E^*, V^*, WY^*, WP^*, WE^*, WV^* \mid \Omega^Y)$,

(4) $V^* = f_V(P^*, E^*, Y^*, L^*, WV^*, WP^*, WE^*, WY^*, WL^* \mid \Omega^V)$,

(5) $L^* = f_L(P^*, E^*, Y^*, V^*, WL^*, WP^*, WE^*, WY^*, WV^* \mid \Omega^L)$,

where P^*, E^*, Y^*, V^*, and L^* are the equilibrium levels of population, employment, per capita income, agricultural land value, and agricultural land stocks, respectively; and Ω^P, Ω^E, Ω^Y, Ω^V, Ω^L refer to vectors of other exogenous variables having a direct or indirect impact on the equilibrium levels. The spatially weighted equilibrium values, WP^*, WE^*, WY^*, WV^*, and WL^*, use a county-level contiguity-based spatial weights matrix, W.

Population and employment are likely to adjust to their equilibrium values with substantial lags (Mills and Price 1984). Similarly, regional income levels and agricultural land and its value are assumed to adjust to their lagged values. The rate and level of agricultural land conversion in the base year is likely to influence the behavior of agricultural land conversion in the current year; or conversely, equilibrium levels of agricultural land adjust to previous period conversion patterns. Thus, distributed lag adjustment equations can be introduced as:

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

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

(8) $Y_t = Y_{t-1} + \lambda_Y(Y^* - Y_{t-1})$,

(9) $V_t = V_{t-1} + \lambda_V(V^* - V_{t-1})$,

(10) $L_t = L_{t-1} + \lambda_L(L^* - L_{t-1})$,

where λ_P, λ_E, λ_Y, λ_V, and λ_L are speed-of-adjustment coefficients between zero and one, and t-1 is a one period lag. Current employment, population, income, land prices, and agricultural land stocks are dependent on their one period lagged levels and on the change between equilibrium values and one period lagged values adjusted at their respective speed-of-adjustment values. Rearranging terms and using Δ to represent the change in the respective variables,

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

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

(13) $\Delta Y = Y_t - Y_{t-1} = \lambda_Y (Y^* - Y_{t-1})$,

(14) $\Delta V = V_t - V_{t-1} = \lambda_V (V^* - V_{t-1})$,

(15) $\Delta L = L_t - L_{t-1} = \lambda_L (L^* - L_{t-1})$,

Including exogenous variables from equations (1) through (5), substituting expressions for equilibrium values, and following Deller et al. (2001) which says that the speed-of-adjustment coefficients ($\lambda 's$) are embedded in the linear coefficients (α, β, and δ), the econometric equations can be specified linearly as:

(16)
$$\begin{aligned}\Delta P &= \alpha_P + \beta_{P1} P_{t-1} + \beta_{P2} W \Delta P + \beta_{P3j} (I + W) \Delta E \\ &+ \beta_{P4j} (I + W) \Delta Y + \beta_{P5j} (I + W) \Delta V + \sum_i \delta_{iP} \Omega^P + \varepsilon\end{aligned}$$

(17)
$$\begin{aligned}\Delta E &= \alpha_E + \beta_{E1} E_{t-1} + \beta_{E2} W \Delta E + \beta_{E3j} (I + W) \Delta P \\ &+ \beta_{E4j} (I + W) \Delta Y + \beta_{E5j} (I + W) \Delta V + \sum_i \delta_{iE} \Omega^E + \mu\end{aligned}$$

(18)
$$\begin{aligned}\Delta Y &= \alpha_Y + \beta_{Y1} Y_{t-1} + \beta_{Y2} W \Delta Y + \beta_{Y3j} (I + W) \Delta P \\ &+ \beta_{Y4j} (I + W) \Delta E + \beta_{Y5j} (I + W) \Delta V + \sum_i \delta_{iY} \Omega^Y + \tau\end{aligned}$$

(19)
$$\begin{aligned}\Delta V &= \alpha_V + \beta_{V1} V_{t-1} + \beta_{V2} W \Delta V + \beta_{V3j} (I + W) \Delta P \\ &+ \beta_{V4j} (I + W) \Delta E + \beta_{V5j} (I + W) \Delta Y + \beta_{V6j} (I + W) \Delta L + \sum_i \delta_{iV} \Omega^V + \eta\end{aligned}$$

(20)
$$\begin{aligned}\Delta L &= \alpha_L + \beta_{L1} L_{t-1} + \beta_{L2} W \Delta L + \beta_{L3j} (I + W) \Delta P \\ &+ \beta_{L4j} (I + W) \Delta E + \beta_{L5j} (I + W) \Delta Y + \beta_{L6j} (I + W) \Delta V + \sum_i \delta_{iL} \Omega^L + \psi\end{aligned}$$

where all variables remain as defined before, I is an identity matrix, and $j \in [1,2]$ such that, for example from equation (16), $\beta_{P3j}(I + W)\Delta E = \beta_{P31}\Delta E + \beta_{P32} W \Delta E$.

The system of equations is estimated using three-stage least squares. This estimation benefits from earlier works by Boarnet (1995), Henry et al. (1999), and Rey and Boarnet (1998) which used an instrumental variable estimation technique in spatial systems of equations models. The existence of right-hand-side spatially weighted endogenous variables poses estimation problems in a system of equations. One approach for solving this problem has been suggested by Anselin (1980) where right-hand-side spatially-weighted endogenous variables can be instrumented on exogenous variables in the system. Using this method, first, the right hand side endogenous variables are predicted using instrumental variables (initial condition variables and a set of exogenous variables). The resulting predicted endogenous variable values are post-multiplied by the appropriate weights matrix to generate predicted spatially-weighted variables; mathematically: $W[X(X'X)^{-1}X'\Delta D] = W(X\beta)$, where W is the spatial weights matrix, X represents a matrix of all exogenous variables, ΔD represents a vector for any right-hand side endogenous variable, and β is a vector of coefficients being estimated. These estimated, spatially-weighted values for the right-hand-side endogenous variables are then substituted into the right-hand side of the original model for estimation using three-stage least squares.

Data

This study uses county level data for the Northeastern U.S. (Connecticut, Delaware, the District of Colombia, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, and West Virginia). Variable definitions are given in tables 2 and3. County-level data for changes in population density, employment density (total employment per square mile), and per capita income were computed from the Regional Economic Information System (REIS) (U.S. Census 2001) and the County and City Data Book (C&CDB). County-level changes in the per acre value of farmland and agricultural land density (farmland per square mile) were calculated from the U.S. Census of Agriculture (NASS 2004) and the County and City Data Book. Initial conditions for these variables are from the same sources. Multiplying the spatial weights matrix times the endogenous and initial condition variables gives their spatially-weighted versions.

Variables for a variety of farmland protection policies examine their impacts on farmland development. Those included in this study are agricultural districts, farmland protection zoning, transfer of development rights, and tax incentives for donation of farmland preservation easements. County level data was not available for these farmland protection policies, thus a dummy variable is used which indicates the presence or absence of these policies at the state level. All policy data are from the Northeast Sustainable Agriculture Working Group (NSAWG).

Two variables measure agricultural performance and its impact on farmland development: agricultural income per farm, and average government payment per farm. Both are computed from the U.S. Census of Agriculture. The percentage of county land in farms (U.S. Census of Agriculture) is included to test whether concentration of farming activity influences the value of land per acre and the extent of farmland development. Employment classification variables, per capita local government taxes (total taxes paid in a county divided by county population), property taxes as a percentage of total taxes, and per capita local government expenditures (at the county level) are also used in the model. Per capita local government expenditures were computed from the REIS and C&CDB. A series of county-level characteristics are used to analyze the impact of local conditions on farmland development. The urban influence code, developed by the USDA Economic Research Service (ERS) (2003), measures the extent of development pressure from urbanized places and ranges from 1 (the most urban) to 9 (the most rural). A code of 1 indicates a county that is in a metro area with at least 1 million residents or more and code 9 represents a non-core county which is adjacent to a micro area and which contains a town of 2,500 to 9,999 residents.

The median value of owner-occupied housing and the unemployment rate represent county characteristics which reflect the attractiveness of moving to a county or staying there based on access to affordable housing and economic opportunities. These variables help measure the indirect impact of these local characteristics on farmland development. The percentage of a county's population (age 25 and above) with a bachelor's degree and higher, along with the percentage of persons in a county below the federal poverty line reflect county characteristics regarding the degree of human capital formation and distribution of poverty. These variables may have significant bearing on county income and employment growth, which consequently may affect the extent of farmland development. State and interstate road density, calculated as miles per square mile, reflect the degree of infrastructure development, which could have a significant influence on county economic growth, demographic change, and consequent farmland development. These variables were calculated by the West Virginia University Natural Resources Analysis Center (NRAC).

Descriptive statistics for all variables in the model are reported in tables 4, 5 and 6. There are 299 counties in the northeastern states; however, the descriptive statistics are based on 290 counties. The county containing Baltimore, Maryland was excluded because it is not included in the Census of Agriculture (NASS 2004). Eight other counties are excluded from this study. Each of these counties, except Philadelphia, reported zero agricultural employment for the study period. Seven of the counties had less than 26 acres in agricultural land, and by 2002, Philadelphia had only 31 acres of farmland. Although these counties are fast growth centers, attempting to measure the impact of their growth on the negligible amount of farmland in these counties will be misleading as there will be almost no change. However, the impact of other fast growing counties on agricultural land in neighboring counties is important and will maintain some of this information from the excluded counties. In addition, the urban influence code for each of the included counties is used to capture part of the missing information due to the excluded counties.

Results

Population Density Change Equation

The coefficient estimates for all variables in the model are provided in tables 7, 8, 9, and 10. Population density change (ΔP) is significantly and positively associated with employment density change (ΔE). This result reinforces similar conclusions in other studies that regions with employment growth attract population. The relationship with per capita income change (ΔY) is negative and significant. Even though it was expected *a priori* that counties with income growth will experience higher population growth, this result for the Northeast indicates that population density is growing in counties with declining per capita income. This result may be picking up an increase in population at suburban and rural locations where income is not growing very quickly. It was expected that higher land prices (ΔV) would lead to a decline in population density; however, the result was statistically insignificant.

Lagged population density (P_{t-1}) is significant and negative, indicating counties with higher initial population density have less population growth in the following time period. The result may also indicate convergence in population density across counties. The spatial lag of the initial condition variable (WP_{t-1}) is positively related with population density change, however, this result is not statistically significant, indicating that initial population density in neighboring areas does not have a significant impact on the change in own-county population density.

The significant and negative coefficient associated with change in population density ($W\Delta P$) indicates that population growth in neighboring counties decreases population density in the county in question. It was expected that population growth in a neighboring county would spillover and result in increasing population due to commuting residents. However, it may be the case that better economic opportunities in fast growing areas are attracting residents away from a rural county resulting in decreasing population there, or that decreasing population density due to flight from urban areas is reflected in increasing population density in a neighboring rural county. Population density change is not significantly related with neighboring county employment density change ($W\Delta E$). Per capita income change in neighboring counties ($W\Delta Y$) has a positive and significant impact on population density change. Interestingly, once income is earned it has no spatial fixity; people can maximize their utility across locations given their income. Hence, a county surrounded by counties with increasing income may attract some commuters to move there, raising overall population density. For example, counties surrounding cities with high income growth may see increases in population as demand increases for characteristics provided by the surrounding counties. Population density is negatively and significantly related with the spatial lag of the change in farmland value ($W\Delta V$). It was expected that higher land values in neighboring counties would drive some residents to locate in the county of interest. One possible explanation for this counterintuitive result may be that counties with increasing land values also have high economic growth, and the economic opportunity in these locations outweighs the disincentive associated with higher land prices.

The results examining local characteristics indicate that per capita taxes ($PerCapTax_{t-1}$) and property taxes ($PropTaxPct_{t-1}$) are significantly associated with decreasing population density, as expected. The value of owner-occupied housing ($MedHsVal_{t-}$) is positive and significant; counties with high housing values are associated with population growth.

Employment Density Change

Change in employment density (ΔE) is significantly and positively related with population density change (ΔP). An increase of one person per square mile increases jobs per square mile by 0.443. A \$1 per acre increase in the value of agricultural land (ΔV) would result in a decrease in employment density of 0.003. Although population growth encourages employment growth, higher land values have the opposite effect.

The initial employment density situation (E_{t-1}) is negatively and significantly related with employment density change. This result suggests that counties with high initial employment density saw a decline in employment expansion compared to counties with low initial employment density. This may indicate a rural renaissance (Deller et al. 2003). The spatial lag of initial employment density (WE_{t-1}) was not significant.

The spatial lag of population density change ($W\Delta P$) is positively and significantly related with county employment growth, suggesting that population growth in neighboring counties can increase own-county job growth. However, employment growth in a neighboring county ($W\Delta E$) is negatively related with employment growth in the county of interest. Counties experiencing high employment growth may attract opportunities from a neighboring county causing employment to decline in that county. Neighboring county income growth ($W\Delta Y$) and the spatial lag of agricultural land values ($W\Delta V$) were not significant in explaining county employment density change.

Employment is analyzed by sectors to see whether employment growth is significantly associated with job creation in specific industries. Both service sector ($ServEmp_{t-1}$) and mining sector ($MineEmp_{t-1}$) employment are positively and significantly related with overall employment growth, however, construction employment ($ConstEmp_{t-1}$) is negative (and significant). Counties with more construction jobs experienced slower overall employment creation. This may indicate construction and development activities in rural counties where overall job growth may have been slower.

There is a significant and positive relationship between employment density change and state ($StatHwyDen_{t-1}$) and interstate ($IntHwyDen_{t-1}$) road densities. Other things remaining constant, an increase of 1 mile of road per square mile would cause employment to increase by approximately 68 jobs and 41 jobs per square mile for state and interstate roads, respectively.

Per Capita Income Change

Change in per capita income (ΔY) is significantly and negatively related with population density change (ΔP), and positively and significantly related with change in employment density (ΔE). A one person per square mile increase in population is expected (on average) to reduce per capita income by $8.38, a similar 1 job per square mile increase in employment would increase per capita income by $8.25. The relationship with the value of land (ΔV) is positive and significant. This result is contrary to prior expectations that high per acre land values drive jobs to lower land value counties and reduce per capita income. The result suggests that counties with significant increases in land values experienced increases in per capita income. There is a two way effect here, the impact of land values on income and the impact of income on land values.

This result may be picking up the fact that counties with income growth also experience land value increases.

The initial per capita income condition (Y_{t-1}) is not significant in explaining income changes, however, spatially-weighted initial per capita income (WY_{t-1}) is negative and significant. This suggests that a county with neighboring counties which had high initial per capita income experienced less income growth.

The cross county effects of all of the endogenous variables, except per capita income, are not significant, thus, income growth in a county is not determined by population ($W\Delta P$), employment ($W\Delta E$) and land value changes ($W\Delta V$) in neighboring counties. However, income growth in neighboring counties ($W\Delta Y$) has a significant effect on own-county income changes. A $100 increase in per capita income in neighboring counties is expected to result in a $43 increase in income in the county of interest, *ceteris paribus*. This result suggests that county income growth is significantly affected by regional income growth patterns.

The local factor results indicate that the per capita tax burden (PerCapTax_{t-1}) is not associated with per capita income change. A positive and significant relationship is found between income growth and property taxes (PropTaxPct_{t-1}). This result is unexpected but suggests that counties with a high proportion of tax income from property taxes experienced per capita income growth. The proportion of county population with a bachelor's degree or higher ($\%\text{BDPlus}_{t-1}$) is positively and significantly related with changes in per capita income. A 1% increase in this percentage would increase per capita income by $225.73, *ceteris paribus*. But, the proportion of a county's population below the poverty line ($\%\text{BelowPov}_{t-1}$) has a greater negative impact such that a 1% increase in the percentage in poverty leads to a $429.53 decrease in per capita income, *ceteris paribus*. Thus, while human capital development increases income growth, increasing poverty may hinder it.

The county interstate density variable (IntHwyDen_{t-1}) is significant. A 1 mile per square mile increase in interstate highway is expected to increase per capita income by $2850.07.

Per Acre Agricultural Land Value Change

A change in per capita income (ΔY) has a positive impact on change in per acre value of farmland (ΔV) whereas a change in employment density (ΔE) has a negative impact. Counties with high income growth are expected to see increases in land values. A $1 increase in per capita income results in a $0.74 increase in the value of agricultural land per acre. This suggests that regional income growth pushes land values upwards through its impact on development of farmland. The negative coefficient estimate for employment density change is contrary to prior expectations that employment growth would exert pressure on existing land uses and result in higher land values. The agricultural land change coefficient (ΔL) has a positive and significant effect. This may indicate that counties with positive agricultural land density changes have higher per acre land values. Or, counties with a greater stock of farmland have higher values of land per acre. One possible explanation for this is that farmland in counties with an expanding agricultural land area is more productive, leading to higher per acre values for farmland.

Counties with high initial own-county agricultural land values (V_{t-1}) experience upward movement in land prices with the estimated coefficient positive and significant. Similarly, counties surrounded by high land value counties experience increases in land values as indicated by the estimated coefficient on the spatial lag of initial land value (WV_{t-1}) which is positive and significant.

Increases in population density in neighboring counties ($W\Delta P$) are positively associated with land value increases in the relevant county. A 1 person per square mile increase in a neighboring county's population is expected to increase agricultural land values by $56.11 per acre. This result is consistent with prior expectations that increasing population in neighboring counties puts pressure on agricultural land increasing the value of farmland. Employment density growth ($W\Delta E$) in one county was also expected to increase land values in its neighbor; however, this variable was not statistically significant. Spatially weighted per capita income change ($W\Delta Y$) is significant and negatively related with land values. It was expected that income growth in neighboring counties would lead to higher land values nearby. This result may be capturing the effect that population and businesses tend to be attracted to high income regions, which would reduce pressure on land values in neighboring counties. The estimated marginal impact shows that a $1 increase in per capita income in a neighboring county reduces land values by $0.74 per acre. The spatial lag of land values ($W\Delta V$) in neighboring counties is positive but not significant. Agricultural land density change in neighboring counties ($W\Delta L$) is significant in predicting own-county agricultural land value per acre. A rise in farmland density in neighboring counties is associated with an increase in the per acre value of land in the relevant county.

The positive coefficients for agricultural income per farm ($AgIncPFarm_{t-1}$) and government payments per farm ($GovtPmt_{t-1}$) confirm prior expectations that farm income and government support payments increase farmland values, although the government payments variable is not significant. All other variables remaining fixed, a $100 increase in agricultural income per farm is expected to raise the value of agricultural land by $2.60 per acre. The proportion of county land devoted to farming ($\%FrmLnd_{t-1}$) is significant and negatively related with per acre county farmland value. For every 1% increase in the amount of county land used for agriculture, the per acre value of farmland is expected to decrease by $92.51. This coefficient simply captures the relationship between county farmland supply and its price, indicating that a higher percentage of land in agriculture reduces its scarcity, hence lowering its value.

Road density variables have positive effects on land value; however, state road density ($StatHwyDen_{t-1}$) is not significant. A 1 mile per square mile increase in interstate density ($IntHwyDen_{t-1}$) results in an increase in farmland values of $10,339.18 per acre. This may be due to the effect of interstate development on regional population, employment, and income growth which directly and indirectly impose pressure on existing land use at local levels in addition to decreasing the supply of land. Development of road infrastructure itself also claims some land from other sectors, including agriculture.

The coefficient estimates for the farmland protection variables indicate that states which have these policies have significantly higher land values compared to states that have not implemented these policies. Aside from agricultural zoning (AgZoning), which was insignificant, all of the other policy instruments have positive and significant coefficient estimates. States that have implemented tax easements (TaxIncentive), agricultural districts (AgDistrict), and transfer of development rights (TDR) have higher agricultural land values with per acre marginal impacts of these policies of $16,019.16, $7,491.82, and $9,756.59, respectively. These impacts could mean that states which have implemented these policies were already experiencing significant increases in land values. Hence, this result suggests that farmland protection policies have been in response to high growth and rapid farmland conversion rather than being implemented as preventive measures.

Agricultural Land Density Change

Change in population density (ΔP) is not significant in determining regional changes in agricultural land stocks (ΔL), but change in per capita income (ΔY) is significant and negative. In line with theoretical expectations, increases in income result in agricultural land conversion to satisfy the demand for growth. Holding other factors constant, a $1,000 increase in per capita income would lead to conversion of 4 acres of farmland per square mile in the county. The positive marginal effect of employment growth (ΔE) on agricultural land conversion was not anticipated. Employment growth may have two effects, market creation and an increase in the demand for land. The net impact will determine the overall change in agricultural land use. In this case, an increase in employment density increases agricultural land density, however, an increase in per capita income decreases it. A significant and positive relationship is observed between change in agricultural land value (ΔV) and agricultural land density change. This positive impact suggests that counties with increasing agricultural land values have less farmland conversion. This result confirms that development is more likely in low-land-value counties compared to counties with high prices for farmland.

The initial condition variable (L_{t-1}) was not significant. The spatially lagged initial condition variable (WL_{t-1}) was significant and positive, indicating that agricultural land density is expected to be high in counties bordering those with high initial agricultural land density.

Estimates of the spatially lagged endogenous variables indicate that population growth in neighboring counties ($W\Delta P$) has a significant and negative effect on agricultural land density. Similarly, increasing farmland values in neighboring counties ($W\Delta V$) lead to a greater loss of farmland in the county of interest. Increasing land values may encourage local farmers to develop their land if the gain from selling is greater than the discounted benefits of using the land for agriculture. Both the spatial lag of income ($W\Delta Y$) and employment ($W\Delta E$) are positive and significant. This result, in conjunction with own-county effects, generally suggests that while own-county income growth increases pressure on existing agricultural land, an increase in these variables in neighboring counties has the opposite impact. Income and employment growth in neighboring counties may create market outlets for farmers in a nearby county while decreasing development pressure in their own county. This conclusion is supported by the negative and significant coefficient for the farm income variable ($AgIncPFarm_{t-1}$), which indicates that less farmland is developed in counties where farm income is higher.

A variable that measures the influence that urban areas exert on farmland development (UrbInfCode) (ranging from 1 for urbanized areas to 9 for rural areas) is positive and significant, meaning that counties close to highly urbanized areas are likely to experience greater farmland losses than counties which are rural. The marginal effect of state road density ($StatHwyDen_{t-1}$) is negative and significant. This supports the idea that better access increases the susceptibility of farmland to development. An increase of 1 mile of state highway per square mile results in a loss of 32.7 farmland acres per square mile.

Results for farmland protection policies show that states which have implemented tax incentives for easement donation (TaxIncentive) and transfer of development rights (TDR) experienced higher levels of agricultural land development than states that did not implement these policies. States using these programs have higher agricultural land conversion at the margin of 198 and 176 acres per square mile, respectively. However, states with agricultural districts (AgDistrict) and zoning (AgZoning) did not see a significant difference in farmland development compared with states that did not have these policies, as these coefficients were not significant. This raises questions regarding the effectiveness of these farmland protection policies.

Conclusion

This study modeled the interaction between regional growth in population, employment, and income and changes in agricultural land value and density. By incorporating endogenous and relevant exogenous factors, marginal impacts on agricultural land are estimated. From the results, at least four fundamental conclusions can be made. One, regional growth may put downward pressure on agricultural land density and upward pressure on agricultural land values. Two, county characteristics such as road infrastructure and closeness to urbanized locations accelerate farmland losses. Three, growth in neighboring counties, particularly in population, can have a negative impact on own-county agricultural land density, i.e., there is significant cross-county and cross-state interdependence in growth and land development patterns. Four, even though states implemented farmland protection policies they still experienced, on average, larger agricultural land density losses than states that did not implement such policies. However, a time-series analysis of these land use policies and associated farmland loss rates would provide a much better picture regarding this issue.

From these general conclusions, it can be suggested that comprehensive cross-county and cross-state land use policy coordination and initiatives may provide better outcomes in managing farmland losses than farmland protection policies that focus on preserving as much farmland in a county as possible while disregarding cross-county growth and development pressure interdependences.

References

Aldrich, L. and L. Kusmin. 1997. "Rural Economic Development: What Makes Rural Communities Grow?" USDA, Agricultural Information Bulletin No. 737.

Anselin, L. 1980. "Estimation Methods for Spatial Autoregressive Structures: A Study in Spatial Econometrics." Cornell University Program in Urban and Regional Studies, Regional Science Dissertation and Monograph Series Number 8. Ithaca, NY: Cornell University, Program in Urban and Regional Studies.

Bell, K.P., and E.G. Irwin. 2002. "Spatially Explicit Micro-level Modeling of Land Use Change at the Rural-urban Interface." *Agricultural Economics* 27(3): 217-232.

Boarnet, M.G. 1995. "Transportation Infrastructure, Economic Productivity, and Geographic Scale: Aggregate Growth versus Spatial Distribution." Available online at http://www.uctc.net/papers/255.pdf (accessed 17 October 2005).

Bowker, J.M., and D.D. Didychuk. 1994. "Estimation of the Nonmarket Benefits of Agricultural Land Retention in Eastern Canada." *Agricultural and Resource Economics Review* 23(2): 218-225.

Brown, D.L., G.V. Fuguitt, T.B. Heaton, and S. Waseem. 1997. "Continuities in size of place preferences in the United States, 1972-1992." *Rural Sociology* 62(4), 408-428.

Brueckner, J.K., and D.A. Fansler. 1983. "The Economics of Urban Sprawl: Theory and Evidence on the Spatial Sizes of Cities." *The Review of Economics and Statistics* 65(3): 479–482.

Carlino, G.A., and E.S. Mills. 1987. "The Determinants of County Growth." *Journal of Regional Science* 27(1): 39-54.

Daniels, T.L. 1986. “Hobby Farming in America: Rural Development or Threat to Commercial Agriculture?” *Journal of Rural Studies* 2, 31-40.

Daniels, T.L., and A.C. Nelson. 1986. “Is Oregon's Farmland Preservation Program Working?” *Journal of the American Planning Association* 52, 22-32.

Deller, S.C., T.-H. Tsai, D.W. Marcouiller, and D.B.K. English. 2001. “The Role of Amenities and Quality of Life in Rural Economic Growth.” *American Journal of Agricultural Economics* 83(2): 352-365.

Dissart, J.C., and S.C. Deller. 2000. “Quality of Life in the Planning Literature.” *Journal of Planning Literature* 15(1): 135-161.

English, D.B.K, D.W. Marcouiller, and H.K. Cordell. 2000. “Linking Local Amenities with Rural Tourism Incidence: Estimates and Effects.” *Natural Resources* 13(3), 185-202.

Gardner, B.D. 1977. “The Economics of Agricultural Land Preservation.” *American Journal of Agricultural Economic* 59: 1027-1036.

Gottlieb, P.D. 1994. “Amenities as an Economic Development Tool: Is There Enough Evidence?” *Economic Development Quarterly* 8, 270-85.

Graves, P.E. 1983. “Migration with a Composite Amenity: The Role of Rents.” *Journal of Regional Science* 23: 541–546.

Henry, M.S., B. Schmitt, K. Kristensen, D.L. Barkley, and S. Bao. 1999. “Extending Carlino-Mills Models to Examine Urban Size and Growth Impacts on Proximate Rural Areas.” *Growth and Change* 30(4): 526-548.

Irwin, E.G., and N.E. Bockstael. 2001. “The Problem of Identifying Land Use Spillovers: Measuring the Effects of Open Space on Residential Property Values.” *American Journal of Agricultural Economics* 83, 698-704.

Kline, J., and D. Wichelns. 1996. "Public Preferences Regarding the Goals of Farmland Preservation Programs." *Land Economics* 72(4): 538-49.

Knapp, T.A., and P.E. Graves. 1989. "On the Role of Amenities in Models of Migration and Regional Development." *Journal of Regional Science* 29: 71–87.

Lapping, M.B., and J.F. Fitzsimmons. 1982. "Beyond the Land Issue: Farm Viability Strategies." *Geo Journal* 6: 519-24.

Lopez, R.A., F.A. Shah, and M.A. Altobello. 1994. "Amenity Benefits and the Optimal Allocation of Land." *Land Economics* 70: 53-62.

Lynch, L., and J.E. Carpenter. 2003. "Is there Evidence of a Critical Mass in the Mid-Atlantic Agricultural Sector between 1949 and 1997?" *Agricultural and Resource Economics Review* 32(1):116-128.

Mieszkowski, P., and E.S. Mills. 1993. "The Causes of Metropolitan Suburbanization." *The Journal of Economic Perspectives* 7(3): 135-147.

Mills, E.S., and R. Price. 1984. "Metropolitan Suburbanization and Central City Problems." *Journal of Urban Economics* 15(1): 1-17.

National Agricultural Statistics Service (NASS). 2004. *2002 U.S. Census of Agriculture*. U.S. Department of Agriculture, Available online at http://www.nass.usda.gov/Census_of_Agriculture/ index.asp (accessed 14 July 2005).

Natural Resource Analysis Center (NRAC), West Virginia University. 2005. *U.S. Major Roads: ESRI Data & Maps 2000*; *Counties (Detailed): ESRI Data & Maps 2000*. Geographic Data Technology, Inc., Environmental Systems Research Institute, Inc. (ESRI).

Nickerson, C.J., and D. Hellerstein. 2003. "Protecting Rural Amenities through Farmland Preservation Programs." *Agricultural and Resource Economics Review* 32(1): 129-144.

Northeast Sustainable Agriculture Working Group (NSAWG). 2003. "Agricultural Policy in the Northeast States: Inventory and Innovation."

Plantinga, A.J., and D.J. Miller. 2001. "Agricultural Land Values and the Value of Rights to Future Land Development." *Land Economics* 77(1): 56-67.

Ready, R.C., M.C. Berger, and G.C. Blomquist. 1997. "Measuring Amenity Benefits from Farmland: Hedonic Pricing vs. Contingent Valuation." *Growth and Change* 28(4): 438-458.

Rey, S.J., and M.G. Boarnet. 1998. "A Taxonomy of Spatial Econometric Models for Simultaneous Equations Systems." Paper presented in the 45th Annual North American Meetings of the Regional Science Association International, Santa Fe, NM.

Roback, J. 1988. "Wages, Rents, and Amenities: Differences among Workers and Regions." *Economic Inquiry* 26, 23-41.

Rosenberger, R.S., and J.B. Loomis. 1999. "The Value of Ranch Open Space to Tourists: Combining Contingent and Observed Behavior Data." *Growth and Change* 30(3): 366-383.

U.S. Census. 2001. *Regional Economic Information System* (*REIS*)*, 1969-1999*. Washington, D.C.: Bureau of Economic Analysis, Regional Economic Measurement Division.

USDA, Economic Research Service (ERS). 2003. "Urban Influence Code." [Online] available from http://www.ers.usda.gov/Data/UrbanInfluenceCodes/2003; accessed 16 May 2005.

Table 1. Moran's I Statistics for Spatial Autocorrelation

	ΔP	ΔE	ΔY	ΔV	ΔL
$W\Delta P$	0.358	0.373	0.211	0.166	-0.230
$W\Delta E$	0.381	0.351	0.166	0.167	-0.187
$W\Delta Y$	0.182	0.185	0.776	0.467	-0.191
$W\Delta V$	0.162	0.240	0.514	0.542	-0.065
$W\Delta L$	-	-	-	-0.056	0.411

Table 2. Endogenous, Initial Condition and Farmland Protection Variable Definitions

Variable	Definition
Endogenous variables	
ΔP	Change in population density from 1987 to 1999
ΔE	Change in employment density from 1987 to 1999
ΔY	Change in per capita income from 1987 to 1999
ΔV	Change in per acre value of farmland from 1987 to 2002
ΔL	Change in agricultural land density from 1987 to 2002
Initial condition variables	
P_{t-1}	Population density in 1987
E_{t-1}	Employment density in 1987
Y_{t-1}	Per capita income in 1987
V_{t-1}	Per acre value of farmland in 1987
L_{t-1}	Agricultural land density in 1987
Farmland protection program dummy variables	
TaxIncentive	Tax incentive for donation of farmland preservation easement (2002)
AgDistrict	Agricultural districts (2002)
AgZoning	Farmland protection zoning (2002)
TDR	Transfer of development rights (2002)

Table 3. Exogenous Variable Definitions

Variable	**Definition**
$PerCapTax_{t-1}$	Per capita taxes (1987)
$PropTaxPct_{t-1}$	Property taxes as a percentage of total taxes (1987)
$GovtExpPC_{t-1}$	Local government expenditures per capita (1987)
$ConstEmp_{t-1}$	Number of persons employed in construction (1987)
$FarmEmp_{t-1}$	Number of persons employed in farming (1987)
$MineEmp_{t-1}$	Number of persons employed in mining (1987)
$ServEmp_{t-1}$	Number of persons employed in the service sector (1987)
$AgIncPFarm_{t-1}$	Agricultural income per farm (1987)
$GovtPmt_{t-1}$	Average federal government payment per farm (1987)
$\%FrmLnd_{t-1}$	Percentage of total land in farming (1987)
UrbInfCode	Urban Influence Code (2003)
$UnempRate_{t-1}$	Unemployment rate (1991)
$MedHsVal_{t-1}$	Median owner-occupied housing value (1990)
$\%BDPlus_{t-1}$	Percentage of population with bachelors degree or higher (1990)
$\%BelowPov_{t-1}$	Percentage of population with income below poverty line (1989)
$StatHwyDen_{t-1}$	Miles of state highway per square mile (2000)
$IntHwyDen_{t-1}$	Miles of interstate highway per square mile (2000)

Table 4. Descriptive Statistics for Endogenous, Initial Condition and Farmland Protection Variables

Variable	Mean	Std. Dev.	Minimum	Maximum
Endogenous variables				
ΔP	16.87	55.28	-494.91	326.32
ΔE	22.55	44.67	-240.37	265.28
ΔY	8015.08	4465.55	2027.00	29382.00
ΔV	2904.74	6328.51	-492.00	74107.00
ΔL	-7.69	24.49	-143.92	115.14
Initial condition variables				
P_{t-1}	361.14	711.11	2.89	6426.30
E_{t-1}	194.75	414.46	1.34	3656.26
Y_{t-1}	14847.90	3879.12	7311.00	27680.00
V_{t-1}	2131.66	2740.89	385.00	29697.00
L_{t-1}	157.64	105.84	0.67	478.84
Farmland protection program dummy variables				
TaxIncentive	0.33	0.47	0.00	1.00
AgDistrict	0.63	0.48	0.00	1.00
AgZoning	0.32	0.47	0.00	1.00
TDR	0.67	0.47	0.00	1.00

Table 5. Descriptive Statistics for Spatially-weighted Endogenous and Initial Condition Variables

Variable	Mean	Std. Dev.	Minimum	Maximum
Spatially-weighted endogenous variables				
$W\Delta P$	17.57	28.41	-66.00	124.75
$W\Delta E$	22.55	22.79	-30.75	120.00
$W\Delta Y$	8059.06	3750.00	2937.50	19245.75
$W\Delta V$	3026.56	4690.82	-800.50	31159.50
$W\Delta L$	-7.92	12.35	-41.75	21.75
Spatially-weighted initial condition variables				
WP_{t-1}	371.66	542.55	21.50	3827.25
WE_{t-1}	201.88	316.66	9.25	2165.00
WY_{t-1}	14892.84	3448.73	8593.00	25786.25
WV_{t-1}	2213.10	2400.39	451.25	15380.25
WL_{t-1}	158.47	83.31	5.50	421.00

Table 6. Descriptive Statistics for Exogenous Variables

Variable	Mean	Std. Dev.	Minimum	Maximum
$PerCapTax_{t-1}$	602.16	318.44	90.00	2503.00
$PropTaxPct_{t-1}$	83.94	13.67	50.10	99.90
$GovtExpPC_{t-1}$	1.38	0.49	0.65	3.54
$ConstEmp_{t-1}$	5083.02	7893.12	48.00	48511.00
$FarmEmp_{t-1}$	1008.19	927.60	0.00	8337.00
$MineEmp_{t-1}$	376.32	717.65	0.00	5479.00
$ServEmp_{t-1}$	22594.19	41970.38	53.00	326659.00
$AgIncPFarm_{t-1}$	50475.71	39302.73	1695.00	260507.00
$GovtPmt_{t-1}$	5492.16	4498.59	0.00	24741.00
$\%FrmLnd_{t-1}$	24.06	15.92	0.40	75.00
UrbInfCode	4.10	2.73	1.00	9.00
$UnempRate_{t-1}$	7.89	2.93	2.90	22.00
$MedHsVal_{t-1}$	86228.28	49036.48	15800.00	299400.00
$\%BDPlus_{t-1}$	17.01	7.94	4.60	49.90
$\%BelowPov_{t-1}$	12.14	6.39	2.60	39.20
$StatHwyDen_{t-1}$	0.36	0.16	0.00	0.91
$IntHwyDen_{t-1}$	0.08	0.10	0.00	0.63

Table 7. Econometric Estimation Results for Endogenous and Initial Condition Variables

Variable	ΔP Equation		ΔE Equation		ΔY Equation		ΔV Equation		ΔL Equation	
	Coef.	**p-value**	**Coef.**	**p-value**	**Coef.**	**p-value**	**Coef.**	**p-value**	**Coef.**	**p-value**
Endogenous variables										
ΔP	-	-	**0.443**	0.000	**-8.38**	0.009	9.74	0.219	-0.041	0.605
ΔE	**0.679**	0.000	-	-	**8.25**	0.076	**-74.84**	0.000	**0.424**	0.002
ΔY	**-0.005**	0.039	0.001	0.390	-	-	**0.74**	0.000	**-0.004**	0.005
ΔV	0.001	0.384	**-0.003**	0.000	**0.09**	0.005	-	-	**0.006**	0.000
ΔL	-	-	-	-	-	-	**58.31**	0.000	-	-
Initial condition variables										
P_{t-1}	**-0.043**	0.000	-	-	-	-	-	-	-	-
E_{t-1}	-	-	**-0.038**	0.042	-	-	-	-	-	-
Y_{t-1}	-	-	-	-	0.15	0.206	-	-	-	-
V_{t-1}	-	-	-	-	-	-	**0.80**	0.000	-	-
L_{t-1}	-	-	-	-	-	-	-	-	0.024	0.721

Bold indicates a statistically significant parameter estimate at the 0.10 level or higher.

Table 8. Econometric Estimation Results for Spatially-weighted Endogenous and Initial Condition Variables

Variable	**ΔP Equation**		**ΔE Equation**		**ΔY Equation**		**ΔV Equation**		**ΔL Equation**	
	Coef.	**p-value**	**Coef.**	**p-value**	**Coef.**	**p-value**	**Coef.**	**p-value**	**Coef.**	**p-value**
Spatially-weighted endogenous variables										
$W\Delta P$	**-1.289**	0.030	**0.597**	0.002	-13.65	0.189	**56.11**	0.078	**-1.256**	0.000
$W\Delta E$	0.032	0.950	**-0.534**	0.059	-9.28	0.589	27.52	0.439	**0.667**	0.083
$W\Delta Y$	**0.008**	0.070	-0.001	0.527	**0.43**	0.001	**-0.74**	0.072	**0.009**	0.060
$W\Delta V$	**-0.008**	0.068	0.001	0.676	0.06	0.506	0.04	0.892	**-0.005**	0.009
$W\Delta L$	-	-	-	-	-	-	**144.07**	0.025	-0.794	0.274
Spatially-weighted initial condition variables										
WP_{t-1}	0.031	0.319	-	-	-	-	-	-	-	-
WE_{t-1}	-	-	0.034	0.282	-	-	-	-	-	-
WY_{t-1}	-	-	-	-	**-0.38**	0.054	-	-	-	-
WV_{t-1}	-	-	-	-	-	-	**0.93**	0.029	-	-
WL_{t-1}	-	-	-	-	-	-	-	-	**0.228**	0.011

Bold indicates a statistically significant parameter estimate at the 0.10 level or higher.

Table 9. Econometric Estimation Results for Exogenous Variables

Variable	ΔP Equation		ΔE Equation		ΔY Equation		ΔV Equation		ΔL Equation	
	Coef.	**p-value**	**Coef.**	**p-value**	**Coef.**	**p-value**	**Coef.**	**p-value**	**Coef.**	**p-value**
$PerCapTax_{t-1}$	**-0.054**	0.098	-	-	-1.08	0.202	-	-	-	-
$PropTaxPct_{t-1}$	**-1.594**	0.004	-	-	**53.14**	0.000	-	-	-	-
$GovtExpPC_{t-1}$	20.662	0.225	-	-	-	-	-	-	-	-
$ConstEmp_{t-1}$	-	-	**-0.431**	0.022	-	-	-	-	-	-
$FarmEmp_{t-1}$	-	-	-	-	-	-	-	-	0.005	0.202
$MineEmp_{t-1}$	-	-	**0.015**	0.069	-	-	-	-	-	-
$ServEmp_{t-1}$	-	-	**0.001**	0.000	-	-	-	-	-	-
$AgIncPFarm_{t-1}$	-	-	-	-	-	-	**0.026**	0.015	**-2×10^{-4}**	0.043
$GovtPmt_{t-1}$	-	-	-	-	-	-	0.405	0.229	-4×10^{-4}	0.915
$\%FrmLnd_{t-1}$	-	-	-	-	-	-	**-92.51**0	0.016	-	-
UrbInfCode	-	-	-	-	-	-	-	-	**11.057**	0.001

Bold indicates a statistically significant parameter estimate at the 0.10 level or higher.

Table 10. Econometric Estimation Results for Exogenous and Farmland Protection Program Variables

Variable	ΔP Equation		ΔE Equation		ΔY Equation		ΔV Equation		ΔL Equation	
	Coef.	**p-value**	**Coef.**	**p-value**	**Coef.**	**p-value**	**Coef.**	**p-value**	**Coef.**	**p-value**
UnempRate_{t-1}	-0.940	0.591	-1.389	0.107	-	-	-	-	-	-
MedHsVal_{t-1}	**0.001**	0.013	-	-	-	-	-	-	-	-
$\text{\%BDPlus}_{t-1}$	-	-	-	-	**225.73**	0.000	-	-	-	-
$\text{\%BelowPov}_{t-1}$	-	-	-	-	**-429.53**	0.000	-	-	-	-
StatHwyDen_{t-1}	54.694	0.414	**67.618**	0.024	205.25	0.919	1660.98	0.671	**-32.696**	0.048
IntHwyDen_{t-1}	23.703	0.664	**41.214**	0.083	**2850.07**	0.054	**10339.18**	0.005	-37.048	0.233
Farmland protection program dummy variables										
TaxIncentive	-	-	-	-	-	-	**16019.16**	0.000	**-197.99**	0.000
AgDistrict	-	-	-	-	-	-	**7491.82**	0.019	-45.767	0.183
AgZoning	-	-	-	-	-	-	296.22	0.887	-7.156	0.738
TDR	-	-	-	-	-	-	**9756.59**	0.003	**-176.00**	0.000
Constant	**127.768**	0.005	7.303	0.474	15.41	0.996	**-18336.91**	0.000	**90.701**	0.094

Bold indicates a statistically significant parameter estimate at the 0.10 level or higher.